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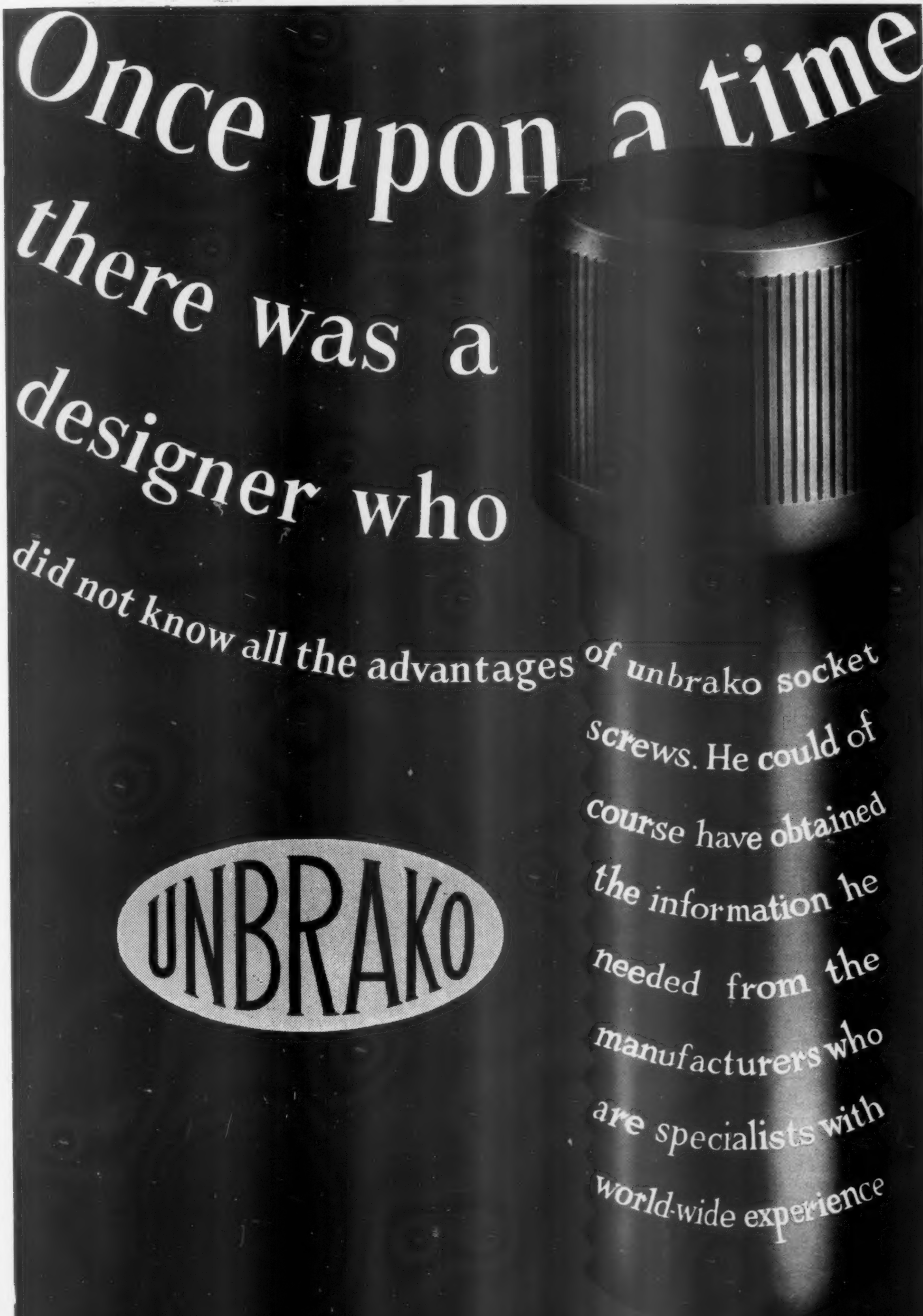
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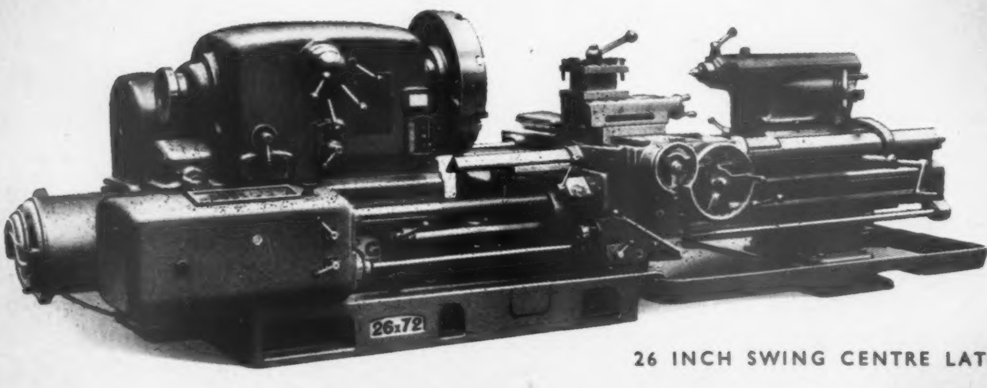


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Some Aspects of Personnel Management

by Dr. A. S. ROY,
Personnel Manager, The British Oxygen Company, Ltd.

RECENTLY in the report on Personnel Administration, one of a series on Ten Years' Progress in Management which appeared in the Transactions of the American Engineering Society,* it was stated that in the U.S.A. the last decade had seen more interest, progress and development in the management of personnel than in any other previous period. Perhaps the most significant change during these ten years had been the change in attitude on the part of top management, which had now begun to realise that the personnel policies and programmes of a company cannot be made effective unless they are carried into effect by the day to day actions and the participation of all levels of management. The views of top executives in the U.S.A. indicated :—

1. That during the past ten years personnel policies have been given an increasingly important place in the agenda of top management councils.
2. That today there is a wider participation in personnel matters by higher executives who represent the principal divisions of a corporation.
3. That today there is more frequent participation by the chief personnel officer in discussions concerning the impact of general management policies on personnel relations.
4. That there are numerous devices for the formulation of personnel policy, all of which involve both top management and personnel representatives, and that there obviously can be no line of demarcation between those policies to be decided upon strictly by management and those to be resolved by the personnel director alone.

In employment procedures there has been a development of techniques in order to find the right employee for each job, so that the greatest nett return is obtained for the company from those applying for jobs. There is also a growing trend of departmental visits and explanations of the job which the applicant is to perform in relationship to the end product.

Increased use is being made of employee handbooks to give information about the company, such as holidays, sickness allowances, location of canteens, first aid stations, lockers, employee activities, etc., and to advise as to company regulations appertaining to hours, discipline, incentive plans, safety regulations and other rules of procedures. Indication of a follow-up programme is for the purpose of welcoming the new employee in a friendly manner and securing his acceptance as a part of the employee group.

In the field of training and education, there has also been great progress in the U.S.A. as outlined in the same report. Next to the proper selection and placement of employees, the most important function in personnel administration is the training and development of all employees. Basically, a training programme is concerned with the development of skills, knowledge and attitude. These three factors make up the programme, which is to be given to employees from any level in the organisation, no matter whether they are new to the organisation or have been employed for many years.

Most companies in the U.S.A. which have fully integrated training programmes, break down the activities as follows :—

1. Orientation, which deals principally with newly engaged personnel.
2. Worker training, which includes all types of job training and general education offered to employees below the supervisory level.
3. Supervisory training dealing with the skills, knowledge and attitudes necessary for a supervisor, stressing the human relations aspect of supervision and an understanding of the administrative tools for organising, planning, controlling and improving the processes necessary for the success of the enterprise.
4. Executive development, which concerns itself primarily with preparation for policy making, long-range planning, creative thinking and action in fields where decisions are of great and lasting significance to many people.

* May, 1953.

The most significant development during these ten years has been in the field of supervisory training and, in the past few years, in executive development.

Although much progress has been made in Great Britain in the personnel field during the same ten years, a further development is necessary along somewhat similar lines. During the last few years the Government, with the help of employers' organisations and Trade Unions, have asked for greater productivity, but up to now the national output has only increased slightly. Employers were asked to introduce improved techniques, mechanised where possible, and to pay more attention to better industrial relations. Representatives of employers and Trade Unions have served on the Anglo-American Council of Productivity and a number of teams has visited the United States in order to bring back proposals to increase the productivity of British industry.

Notwithstanding all this there has been only this slight increase in national output. It is my opinion that much could be done with the the existing man-power and equipment by concentrating more effort on the human relations in industry and with better selection and training, greater productivity could be obtained.

Selection and Placement

The effective application of personal effort calls for proper selection and placement of each individual in the organisation : it is only when he is on work for which he is fitted that an employee is able to utilise his ability to the best advantage to himself and the company.

The Employment Officer has the responsibility for securing application from enough people of the proper type and experience. This includes doing the preliminary interviewing or sifting so that the departmental representatives have carefully selected applicants from which to make the final choice.

Care and skill can be wasted unless a firm's employment procedure as a whole is properly organised. This should provide for :—

1. Means of determining, over a period in advance, the numbers of additional employees required for all categories of work.
2. Advance recruitment of candidates to fill expected vacancies.
3. Proper reception of candidates applying for jobs.
4. Means of obtaining preliminary information about each candidate.

An organised scheme for dealing with these matters is essential to ensure economy in the use of available man-power.

There are two aspects—both equally important—of the process of selecting and placing individual candidates in jobs. They are :—

a. the assessment of the job in terms of the demands it makes upon a person who is to do it successfully and without undue strain; and
b. the assessment of the candidate in relation to those demands.

Good selection will achieve financial economies and in order that the person responsible for this particular function may carry out his responsibilities successfully, a thorough knowledge of all jobs is essential. This means that a detailed Job Analysis should be made and this analysis is useful in other ways than for selection—it points out any training requirements and is necessary for any Job Evaluation programme.

The objective is to find out what the job demands of the worker and to express these demands in the form of a clear job specification against which individual candidates can be assessed. The human demands of any job can usefully be classified under five headings, viz :—

i. Physical Capacity and Health.
ii. General Intelligence.
iii. Special Aptitudes (e.g. verbal facility, manual dexterity).
iv. Attainments (including general education and technical skills).
v. Qualities of Temperament and Personality.

Aptitude tests are a useful guide to recruitment provided that it has been shown that by using these tests a more satisfactory worker for the particular job is obtained. These tests are never a substitute for an interview, but they are a helpful aid to the Employment Officer.

The employment interview has three main objectives. The first is to find out whether the candidate is suitable for employment in the organisation and if so, in what particular job his talents can best be used to mutual advantage.

The second is to give him an accurate picture of the job or jobs for which he is being considered and their prospects; details of pay and conditions of employment; and a broad outline of the nature of the company's business and of its aims and policies—especially the policies concerning management-

employee relationships. A candidate who is fully informed on these matters is easier to interview; and the risk of his becoming dissatisfied later owing to some misunderstanding about the job and its conditions is minimised.

The third objective is so to conduct the interview that, whether the candidate is engaged or not, he feels he has had fair treatment. Unsuccessful candidates can be greatly helped if they are given practical advice about the type of work which may be suitable for them and what course of action they may best pursue.

Under conditions of full employment it is often quite easy to say that the person chosen is the best available, but in order to reduce labour turnover and to increase productivity we must make the most efficient use of employees.

Considerable research and experiment has been undertaken in recent years on matters of personnel selection. During the war extensive use was made of scientific methods for the armed forces. Courses have been arranged by the National Institute of Industrial Psychology on selection and testing technique and these courses have proved of great value. Much more attention must be given in the future to the selection of supervisors and a recent survey which has been carried out by the National Institute of Industrial Psychology proves that more efficient methods of selecting supervisors need to be developed. A number of companies have employed the group selection technique in appointing supervisors and several are very pleased with the results obtained.

Education and Training

The effectiveness of the efforts of any group of workers depends directly upon the degree to which each individual is trained in the doing of the tasks assigned to him. Each department in a company is made responsible for getting work done and therefore must be held responsible for doing this training, which includes general or introductory training, training in methods of doing work and also training for promotion when this is necessary in related jobs offering promotional possibility.

"Education and Training" has now come into its own as a major division of personnel work. If we have selected the right person for the job, we have next to introduce him or her properly to the organisation.

There are two aspects of staff training which are important to employees' satisfaction and subsequent efficiency.

1. The newcomer should not be left to wander about picking up essential information concerning the organisation, employee services, the rules and conditions of employment and the Company's Staff policies. Instead we should make a person feel at home in an entirely new environment by a friendly reception and by giving comprehensive information about the Company.

2. We should regard the introductory training course as a means of assisting the individual and the company in regard to job placement and assessing the individual's potential value. Good induction training schemes are therefore designed to cover all the information about the organisation, the people in it, and the job, that the new employee needs to know. While the procedures and methods used for this purpose do, of course, vary for different ages and grades of employees, a set of definite procedures, suitable for each grade and age-group should be established, and always carried out, no matter how few or how many employees may be engaged at a given time. An induction course is essentially simple and realistic. The new employee wants to get started on the real job, so the preliminaries are limited to the obviously necessary matters which will arouse his interest by providing answers to the questions that are foremost in his mind at the time.

When an employee starts on the particular work which has been chosen for him, he must be properly trained in the doing of that work.

It is therefore essential that the person who is doing the training has a definite skill in instructing. The Ministry of Labour introduced, in 1944, Training within Industry, which consisted of three separate training programmes, one of which was "Job Instruction". This programme sought to develop in Supervisors the necessary skill in giving clear and unambiguous directions and in instructing workers in what they had to do and how they should do it. This programme lasts five half-days and is invariably conducted within working hours and instruction is entirely based on informal methods. The courses consist of from eight to ten supervisors.

Up to last year more than 3,000 firms had adopted some or all of the T.W.I. programmes and more than 200,000 supervisors have participated in the Job Instruction programme.

Supervisory Training

The development of supervisory personnel in any industry must not be left to chance. New leaders must be produced by intelligently planned programmes of personnel development. It used to be considered enough to lay down orders and issue regulations; now it is more constructive and productive to

explain clearly the reason behind instructions, and conditions that create policies. A clear explanation of organisation procedures and policies has reaped its dividends, both in creative suggestions and in the type of company harmony that causes better products to be manufactured in a shorter period of time. Therefore, executive and supervisory training programmes today are designed not only as channels for instruction in the details of supervisory technique, but also the permanent way for the continuous interchange of ideas that is so essential.

Industrial organisations are becoming more complex because of increased size and specialisation of operations. For this reason, there has never been a period in the life of most of our industrial foremen and other supervisors when a knowledge of the fundamentals of organisation and management was more needed than is the case today. Those organisations in which each foreman fully understands his responsibilities, his authority, his relationship to others in his organisation and management aims and desires as they apply to his work, will be in the best position successfully to meet these new conditions.

The difference between an executive and a foreman is coming to be more of a question of the extent and amount of responsibility than of the kind of responsibility. Each executive and foreman, to the extent that these factors are related to his work, is expected to be familiar with the organisation—the operating policy, the personnel policy, the production process, the quantity of the production, the cost of materials, machines and operation.

The growing similarity of the kind of responsibility naturally leads to a need for greater co-ordination of the whole management group so that there may be uniformity of interpretation of clearly understood policies. The forces which produce the similarity of responsibilities not only make it possible to use the same approach in training executives and foremen, but make it almost essential. The result has been that there has been an increase in the number of training programmes which are designed both to co-ordinate the thinking of all levels of supervision.

Management in a manufacturing business is interested in production, of a quality, at a cost and in a quantity at a time which will satisfy demand. All these factors have a direct bearing on the actual process of production and in a study of the supervisor's or foreman's responsibilities, consideration must be given to the importance of *cost control, quality control* and *planning (or budgeting)* .

In carrying on the production process, the foreman or supervisor directs the labour in the use of machinery, equipment and materials in accordance with established methods and procedures. Therefore personnel problems are an important factor in the work of supervision.

Each member of management, then, within the limits of his assignment, must control quality, quantity and cost by :—

a. practising good planning;
b. ensuring adequate equipment;
c. supplying proper material;
d. developing effective methods;
e. building and maintaining an effective work force.

A supervisor's job is to work within the limits of his assignment and within established policies and procedures, so that he will direct the employees in their use of equipment and materials in accordance with established methods in order that his and the Company's responsibility for quality, quantity and cost will be met.

Regardless of position, each supervisor :

i. Must know his job.
ii. Must know his relations with others.
iii. Must effectively direct the activities of those responsible to him.

Only by such knowledge and by its effective use can any supervisor make full contribution to effective management.

The principles of effective management are as follows :—

1. Group together similar or related activities.
2. Place responsibility for results.
3. Delegate authority and establish definite lines of authority.
4. Make sure each member of management is fully informed as to :—
   a. The exact nature of his activities and responsibilities.
   b. The scope and limits of his authority.
   c. Policies and procedures as they apply to his work.
   d. His relations to other individuals and groups.

In order to apply these principles of effective management the following must be done :—

1. Each job must be defined.
2. Policies and procedures affecting the work must be made available to the person responsible.
3. Relations with others must be identified and made available.
4. Scope and limits of authority must be outlined.
5. Definite understanding as to right to decision must be developed between each supervisor and his immediate superior.

Each supervisor from foreman upwards must, within the limits of his assignment, do these necessary things if management is to be effective.

A company, to succeed, must have satisfactory individual output because the results of the whole company can be no greater than the sum of the accomplishments of all the individual employees.

The individual's contribution will depend on his attitude, his will to do. Employees who are recruited with the requisite natural ability and physical condition, and are given the necessary training and provided with the correct materials, equipment and methods, must have the correct attitude if they are to do their utmost.

Therefore foremen must be trained in the methods of getting ideas across to employees and also in what they should do in solving employees' problems.

One of the most important responsibilities of every member of management from foremen upwards is to get ideas across.

Whether the supervisor is seeking information or a decision, or whether he is seeking to get someone to do something or accept a decision, he must effectively make the particular employee or employees fully understand.

Many mistakes can be traced to insufficient and misunderstood instructions. The supervisor's instructions are often ineffective because :—

1. He takes too much for granted.
2. He thinks the employee knows.
3. He thinks the employee does not need to know.
4. He does not take time.

He should therefore :—

i. State the problem briefly but completely so that its significance and importance can readily be understood.
ii. State the solution, the proposed procedure and the part the other person is expected to play.
iii. State the reasons why the proposed solution is the best available.
iv. State the results anticipated from the recommended course of action, from the new method or from the changed procedure. Only by getting ideas across can supervisors, regardless of position, meet their full responsibility for satisfactory results.

The Direction of Human Effort and Leadership

The application of human effort individually or in groups must be directed and co-ordinated if it is to be effective. The various departmental heads and supervisors are responsible for organising employees, assigning tasks, issuing instructions, correcting mistakes, fixing responsibilities for results, building up and maintaining the necessary co-operative effort between working groups and maintaining discipline.

The effective application of human effort in any enterprise calls for leadership. To be most effective, leadership must inspire men to want to do. This comes partly as a result of confidence in the ability and integrity of the leader, but it also depends to a very considerable degree on the method of dealing with people and his knowledge of individual departmental managers and individual employees.

It is evident, therefore, that a supervisor should be a good leader. An essential part of his job is dealing with employees, in directing their activities and interpreting company policies to them.. Not only must he set a good example himself, but he must inspire his employees by sympathetic interest, and fair dealing in individual cases.

The following is an actual statement made by a foreman on what he considered were the factors which make a good foreman :

" We hear a lot about morale, just what is morale and what does it mean to a foreman? Like a lot of other things, not easy to put your fingers on. Morale means the way a man feels about his job, it means he likes his work or dislikes it, whether he has confidence in his superior or distrusts him, whether he is friendly with his fellow workers or quarrelsome, whether he does a full day's work of just enough to get by, that is what morale means. Now what can we do about it? Let's not fool ourself, we can improve morale when we remember how our morale is affected by the way our superiors act and talk. I know that my men must feel the same way about how I act and talk, and too, I must remember that a smile or a word of encouragement once a week does not make me a good foreman; it is how I act and talk all the time that counts. Good morale is something we must build up ourselves by our own conduct and handling men at all times; men work better because they want to, not because they have to. The foreman should use praise rather than criticism; when we criticise work or correct mistakes we should do it in a way not to hurt a man's pride or self-confidence. I should never act as if I thought a worker is too dumb to understand, or annoyed if I have to repeat instructions the second time; furthermore the minds of some men are slow to grasp things, while the minds of others are fast; I should not be impatient with the slow thinkers—they often develop into the best workmen. I should avoid sarcastic remarks or wisecracks that make others feel uncomfortable; I should try to make every man like his job; therefore, whether a man likes his job or not is important to my success as a foreman and as much responsibility as it is the man himself, for I can make my department a good place to work or a place where men do not want to work.

" Knowing what he is to do and how are the first requirements to make a man satisfied in his job, nothing will do more to unsettle a man in his work or interfere with his work than confusion or uncertainty in his mind about what he is to do and how he is to do it. I should see that every one of my men understands his job, when instructing a man in his work I should do it thoroughly; I should remember that old stuff to me is probably new to him. I cannot expect men to take orders and follow blindly; I should not shout out questions and refuse to answer them; forceful language may drive home a point, almost every man resents being cursed at; it is smart for me to avoid swearing and shouting at my men; anger on my part may usually generate anger in other men; and I do not want my men nursing a grouch for days because I lost my temper; I should never criticise one worker to another; this causes friction among the men and makes them distrust me; also destroys morale. To say my men are doing a job wrong does not help matters, unless I tell him how he is doing it wrong. When I criticise a man for his work at the same time I should encourage him to feel that he can do better.

" It is surprising how a commonplace remark as " how is it going now, Jim? " can take the sting out of a criticism and make them feel right about it. I do not want to have to eat my words, so I should guard against jumping to conclusions and to be sure to know what I am talking about before I criticise anyone; when I make my criticism I should listen to the other fellow's story—there might be a very good reason for what he did. If a man has a " bawling out " coming to him I should do it without anger and in private, not in front of the other men as that causes hurt pride and resentment and destroys any good that might be accomplished. In plants where you find good working morale you find good foremen; where you find poor foremen you find bad morale.

" There is a way of giving orders agreeably and a way of doing it disagreeably. The agreeable way will bring better results; I would not be a call-me-mister kind of foreman; that is often a sign of weakness more than a sign of strength. I will make is my business to know every man my name and whenever possible greet them by their first names, most men are uncomfortable when you mister them—they prefer to be called 'Bill', 'Charles', or 'Jack', etc.

" Men like me to be interested in their ideas or opinions about the work; I should be a good listener once in a while, it will get some valuable help; under no circumstances would I rub off or cut him short. A foreman must not accept gifts, loans, or special favours from any of his men. He should be sure not to ignore or overlook the men who go on doing a good day's work day after day; frequently good dependable men are overlooked, and others who force themselves on the attention of the boss get the breaks. This, I believe, is the way of handling men."

The practical application of these personnel principles remain the responsibility of all those engaged in the management and supervision of labour. The responsibility for implementing these policies, founded upon enlightened thinking, must be set fairly and squarely upon the shoulders of all levels of supervision, and the degree of success of a company's policies depends very largely on the attitudes of these people.

THE MANUFACTURE OF PLATE GLASS

by SIR HARRY PILKINGTON

Presented to a General Meeting of the Institution of Production Engineers at the University of Leeds, 9th November, 1953.

Sir Harry Pilkington

Sir Harry Pilkington entered the well-known family glass manufacturing firm of Pilkington Brothers in 1927. He became a director in 1934 and is now Chairman of the Company and a director of its subsidiaries at home and overseas.

Sir Harry is responsible for the commercial policy of his firm rather than the technical aspects and he has travelled widely and made frequent overseas visits in connection with Pilkington Brothers' activities in other countries. From 1944 to 1952, Sir Harry was Chairman of the Executive Committee of the National Council of Building Material Producers.

He was appointed President of the Federation of British Industries in 1953.

WHEN Sir Cecil Weir did me the honour of approaching me a few months ago to ask me to deliver this Lecture, I made it clear that I was not an engineer in any shape or form and that I could not give a highly technical Lecture. In my own firm I have always been connected mainly with the sales side of the business and most of the terms in which you talk are far above my head. I thought, therefore, that it might be of the greatest interest to you if, instead of a detailed engineering talk centred on a particular subject such as I believe you have had in the past, you had one that was a great deal more general in scope, dealing with one part of the British glass industry that has had an interesting evolution during past generations, and that I should ask one of my colleagues to provide me with the technical facts that are material to the subject.

Development of the Industry

First of all, however, I think that you ought to know something of the position of the plate glass industry (since plate glass is the subject of this talk) in this country and the world. In the 1870's when my firm went into plate glass manufacture, half a century after it had started sheet glass manufacture, it was quite a venture as there were already well established plate glass manufacturers in this country, and many continental competitors. In a series of technical revolutions, however, manufacture has changed from completely discontinuous to completely continuous processes, and this has meant that the size of unit for economic manufacture, and its output, has grown very much more rapidly than the demand for the product, with the result that now the whole requirements of the British Empire for ordinary plate glass, in the thicknesses most usually purchased, can easily be met from two manufacturing units only—one at Doncaster and one at St. Helens. There are now far fewer manufacturers overseas than there were 50 years ago and for some 35 years there has been only one manufacturer of plate glass in Great Britain or indeed in the British Empire, and who, during that time, has so much improved productivity that plate glass for ordinary purposes is now manufactured from only two units; all other manufacturers in this country have long ago disappeared through not having kept pace with the growth of technical development, particularly of engineering. This has lessons and dangers for the future, and inconveniences for the present on which I will enlarge later.

Because it can only be undertaken economically on a very big scale, plate glass manufacture for competitive supply to the world markets is virtually confined now to the U.S.A.; to this country; and to Belgium, France and Western Germany; only in the U.S.A. are there more than two manufacturers and

even there, probably 95% of that sold in competition is made by two firms. In a few countries smaller uneconomic factories operate behind high tariffs for their own market, and one day we will probably find Japan and Russia in the world markets too.

Flat glass, whether plate or sheet, is used mainly in the building, furniture and motor industries; on the whole people do not buy glass for its own sake, and the level of demand can only be slightly influenced by anything the producers can do over a short period; The fact that the main use of plate glass is in the motor car industry, one that all over the world is particularly subject to fluctuations, brings us problems that are made extra difficult by our large scale inflexibility, made still more inflexible by the fact that ours is essentially a 168-hour a week process; so much for the general economic background.

The Basic Processes

Glassmaking and, in particular, the making of flat glass in its several varieties, is an activity about which relatively little is known to those who are not personally engaged in the industry. It may, therefore, be of interest to describe the basic processes involved before dealing with the historical development, in a technical sense, of methods employed in making plate glass and their effect on efficiency and productivity.

With few exceptions which, for the purpose of this Lecture, are unimportant, flat glass in its several varieties is known, colloquially, as a "soda-lime" glass. This means that in addition to the silica which is by far the largest constituent, soda and lime come next in order of importance. There may be, and usually are, smaller quantities of other constituents such as magnesia and alumina, but for our purpose it is sufficient to say that flat glass is made of (1) silica, (2) soda, and (3) lime.

The raw materials corresponding to these constituents are, respectively, (1) sand, (2) soda ash and saltcake, and (3) limestone and dolomite. These materials, finely divided as found in nature like the sand, or mechanically ground as the limestone must be, are assembled in their correct proportions and intimately mixed by special machinery to form the batch—or, as it is known to glassmakers, "frit".

This frit goes into a furnace where it is subjected to a progressively rising temperature reaching a maximum of 1500° Centigrade or thereabouts, and in the process a succession of chemical reactions between the constituents results in the formation of molten glass. Continued exposure to high temperature has the effect of removing imperfections, such as bubbles, after which the molten glass is cooled down to a temperature appropriate to the particular process which, in converting the glass from a plastic to a solid state, will also deliver it in the required form.

There are three main forms of flat glass. These are—sheet glass in universal use for the windows of smaller houses; rolled glass in its many patterns for use where translucency is needed or is sufficient; and plate glass for shop windows, mirrors, motor cars, larger domestic glazing, and innumerable other purposes. In choosing plate glass as my subject, I have been influenced by the fact that, because of the greater diversity of the operations which lead to the final product, it provides a broader field of interest than either of the other two. It will, however, help you to form in your minds a more comprehensive picture of the technical aspect of the matter if, by way of an introduction to plate glass in greater detail, I give you a brief description of the methods employed in making sheet and rolled glasses.

Sheet and Rolled Glasses

In the modern method of making sheet glass, frit is fed into one end of a long continuous furnace where it is converted to molten glass. This, in passing along the furnace, experiences a cycle of temperature variation by means of which it is refined and then cooled. At the exit end of the furnace the glass, still molten, and at the correct temperature for the purpose, forms a bath from which a ribbon of the desired width is drawn vertically upwards. For the same thickness the rate of production is dependent on the viscosity and therefore the temperature of the glass in this bath. The thickness itself is dependent on the speed of draw; the higher the speed the thinner the glass is drawn. As soon as the ribbon is formed, rapid but carefully controlled cooling is brought about and when the ribbon has become sufficiently solidified to ensure that its surfaces will not be easily injured, it is gripped and propelled upward by rotating rollers through a vertical tower in which it is annealed and then cooled to a temperature at which it can be handled. It is then in its final form: at the top of the tower, sheets are cut from the moving ribbon and in due course find their way to the warehouse, where there may or may not be further cutting before despatch to the customers.

As a finished product, sheet glass differs from plate glass which, as will be explained later, is polished mechanically, by the fact that its polished surface has a natural "fire finish", as it is termed, and it is for this reason that the ribbon after it is formed must not come into physical contact with a roller or other solid body, until sufficiently solidified to be incapable of taking an impression. The process is, however, a very sensitive one and in spite of temperature control to the highest possible standards of precision, it is characteristic of even the best sheet glass that there are slight departures from flatness and uniformity of thickness which manifest themselves in optical distortion. While, therefore, it serves its purposes well and cheaply, there is this characteristic of distortion which distinguishes sheet glass as a commercial product from the much more costly mechanically polished plate glass.

In the case of rolled glass, the molten glass having been made in a continuous furnace in very much the same way as that described for sheet glass, arrives at the delivery end at a suitable temperature and from this stage the process becomes quite different. The ribbon, instead of being drawn from a bath, is formed by passing the molten glass between two horizontal water cooled metal rollers, whose distance apart determines the thickness. If either roller has a surface

pattern, this is imprinted in obverse on that surface of the ribbon which has been in contact with it and so we have in great variety the figured rolled glasses. The ribbon of glass is then annealed and cooled in its passage down a long horizontal lehr.

If the rollers are plain instead of patterned, they will produce glass with plain surfaces but they will not be polished surfaces. Having been formed by physical contact while still soft, they lack what has already been referred to as the natural fire finish of sheet glass and, if they are to be converted to polished surfaces, they must be ground first and then polished by mechanical means and this, in principle, is how plate glass is made. The process of rolled glass formation also differs from sheet in that the rate of output is much less dependent on the viscosity of the glass and much more on the speed of rotation of the forming rollers. Much higher speeds can therefore be achieved. Quality is less important and the process less sensitive.

Changes in Manufacturing Methods

This brings us to a more detailed consideration of the technical aspects of plate glass manufacture and I shall begin by tracing the history of its recent development, so that, in due course, it can be shown how technical progress has contributed to higher efficiencies and productivity.

It is unnecessary to go back more than about 50 years, when methods which now seem primitive had for generations served the needs of glass-making countries whose export markets were more easily won and preserved than they are to-day. During the last half-century or so, there have been revolutionary changes in methods and I shall try to describe to you the course of technical progress in this country and then relate it to results in terms of economic progress.

Earlier in this Lecture, I told you how few manufacturers of plate glass there are in the world and that there is only one surviving manufacturer in the Empire. This might seem to imply that plate glass is in a very comfortable monopolistic position and that there is no need to concentrate on further improvements in order to preserve or increase the demand. Such an impression would be completely false and unjustified. During this century the abandonment of the old method of manufacturing sheet glass (under which it was made as a cylinder and then later flattened), has given place to a method where sheet glass is drawn continuously from the tank. The result is a very great increase in flatness, together with a cheapening of the product, by the complete omission of one of the major processes of manufacture; but the greatest advantage that plate glass had over sheet glass lay in its flatness; the more that sheet glass improves, the less does the advantage of plate glass become. Moreover, under the newer methods of manufacture sheet glass can be made in those same thicknesses that used to be regarded as the preserve of plate glass.

Apart, therefore, from competition with other manufacturers in the export markets of the world—and since we export, directly or indirectly, half of our total production, foreign competition in the world markets is a material factor—the need to fight for the survival of plate glass against the encroachment of sheet has been a constant driving force to compel simultaneously a further improvement in quality and a vast reduction in cost; a reduction in cost usually achieved by greater output from the same plant and therefore only materialising fully if demand also increases.

Plate glass will never intrinsically be as cheap as sheet glass. Sheet glass inherently is made in one process only; plate glass inherently is cast rough and must have the surface subsequently ground and polished. This is more expensive and must produce a finer quality to justify its price.

Moreover there are some sizes which it would be quite uneconomical to manufacture in sheet glass. The motor trade, for instance, in particular, is very sensitive to price and plate glass cannot be manufactured economically in large sizes alone. We must therefore continue to fight to reduce costs in competition with sheet glass, whether manufactured by ourselves or by anybody else, if we are to keep plate glass in commercial and economic production on its present vast scale. I do not think this has been the only driving force, or even the principal one, behind our inventions, but I do say that if the plate glass industry had not had the benefit of three major technical revolutions during the past thirty or forty years, it would survive now only on a small scale, at very high prices, for shop windows, high quality mirrors, thick portholes, and other special uses.

Fifty years ago, plate glass was made, not in continuous furnaces in which frit went in at one end and molten glass came out at the other, but in refractory clay pots (Fig. 1). These pots occupied the floor of a furnace for a period of about twenty-four hours, during which they were filled with frit, the frit was turned into molten glass and after having been refined and cooled, each pot, containing about a ton of molten glass, was withdrawn from the furnace, emptied of its contents and returned to the

Fig. 1
A clay pot in the furnace preparatory to filling with the raw materials

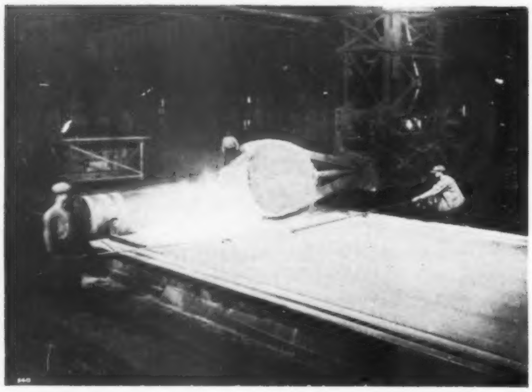


Fig. 2

Pouring and spreading the molten metal prior to rolling

furnace to undergo the next cycle of operations. The number of pots in a furnace was anything up to twenty and if a pot survived twenty cycles, or in other words, lasted twenty days, it had earned a favourable obituary.

The emptying, or casting, process consisted of tipping the pot in such a way that its contents, now fairly stiff in consistency, formed a bolster across one end of a large iron table (Fig. 2). The bolster, while still plastic, was rolled out to form a plate by a heavy iron roller which, near both ends, was supported by steel strips equal to the desired thickness and depending upon this thickness the plate might be anything up to 150″ wide x 250″ long. In shape it was roughly a rectangle with parallel sides but irregular ends. Thermal distortion of both table and roller was unavoidable and with an average thickness of 10 or 12 millimetres there might be a variation over the area of the plate of 2 or 3 millimetres. The plate, substantially solidified, was then transferred to a series of annealing chambers constituting what is known to glassmakers as a " lehr " from which, after it had been annealed and slowly cooled over a period of some hours, it was withdrawn in readiness for grinding. This operation was carried out in a machine in which a flat-topped circular iron table, 22 ft. in diameter (Fig. 3), carrying a patch-work of rough-cast glass plates laid in Plaster of Paris, revolved horizontally. Supported by the top surface of the glass were heavy iron runners, having their circular under-faces intersected by grooves through which water-borne sand could flow to distribute itself over the area of the table. The runners, free to revolve, did so in virtue of their frictional contact with the rotating glass-topped table and so the glass was ground until all traces of its original rough cast surface had disappeared. Continued grinding with successively finer grades of sand until the glass had acquired a frosted appearance of very fine texture completed the grinding operation.

The table was taken from the grinding machine and transferred to the polisher where runners operating on the same principle as the grinder runners, but consisting of a multiplicity of felt-covered discs fed with water-borne rouge, converted the finely ground surface to the highly polished one which we associate with plate glass. The table was then withdrawn from the polishing machine, the glass plates lifted and relaid with the other side up, and the processes repeated.

For the next fifteen years or so the methods which I have described remained substantially unchanged in principle and progress consisted in the use of bigger pots and furnaces, the substitution of a casting process in which, by the use of two revolving rollers which received the molten glass from a shaped container, plates of better shape and greater area were produced, and a change-over from a grinding table of 22 ft. diameter to one of 36 ft., which brought about some improvement in efficiency and productivity.

The Economic Aspect

At this stage I suggest that we take ourselves back thirty-five years and, without attempting to assess their significance in numerical terms, consider some of the more obvious shortcomings, from an economic point of view, of the methods which have been described.

With negligible exceptions, plate glass is sold in rectangles and a circular grinding table is not of the shape which one would choose to accommodate rectangles to the best advantage. To complete the circle, and its whole area must be filled, a substantial proportion of the glass must be in small and irregularly shaped pieces which, when they reach the warehouse, have little or no usefulness. The irregular ends of the rough cast sheet also involve wastage. Variation in the thickness of the rough cast plate means that not only do the thicker portions consume glass which, had there been less variation, would have increased the useful area of the plate, but they consume time, wages and power during their removal by the grinding process, and which all on one table must be ground till the thinnest sections have been

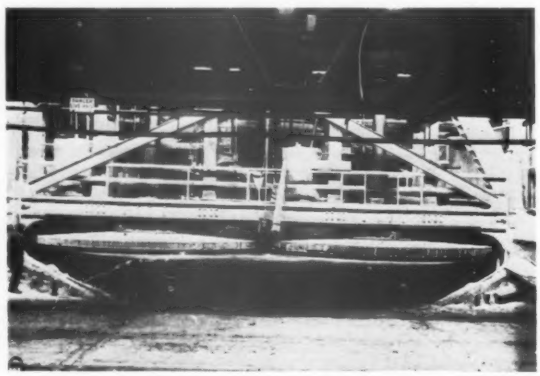


Fig. 3

Disc Table in position beneath the grinding heads

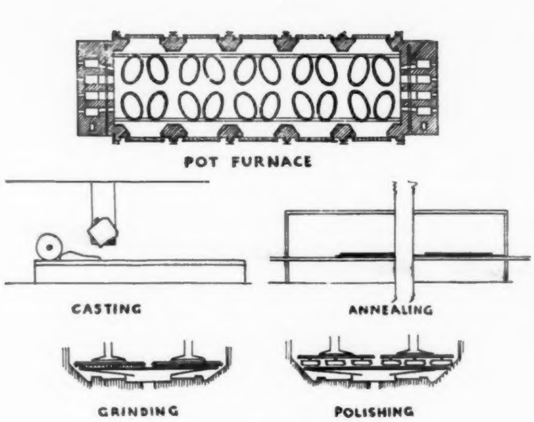


Fig. 4

fully smoothed. The wide temperature variation necessary for the glassmaking cycle must be followed by the massive furnace structure over every twenty-four hour cycle and this is reflected in a high fuel consumption. In terms of electrical power the same thing applies to the grinding cycle for which the consumption curve is not very far from a triangle with, as a consequence, low average operating efficiencies for the electrical machines. The picture is therefore one of a sequence of processes which could hardly be further removed from what is regarded to-day as a continuous process and which with all its sources of loss and wastefulness of manpower, fuel and glass, was an ever-present challenge to plate glass makers to look for progress along radically new lines.

The chart shown in Fig. 4 gives only a very elementary indication of sequence but shows five distinct processes.

By the end of the First World War a good deal of thought had been given to the possibilities and following the results of experimental work which seemed to justify adventuring further, trials on a pilot plant scale led to commercial production in a small way of a continuous rough cast ribbon and also of a finished plate glass, ground and polished by methods much more nearly continuous than the old circular disc process.

The rough cast ribbon process has already been described in outline in connection with the making of rolled glass and, indeed, the first trials on a

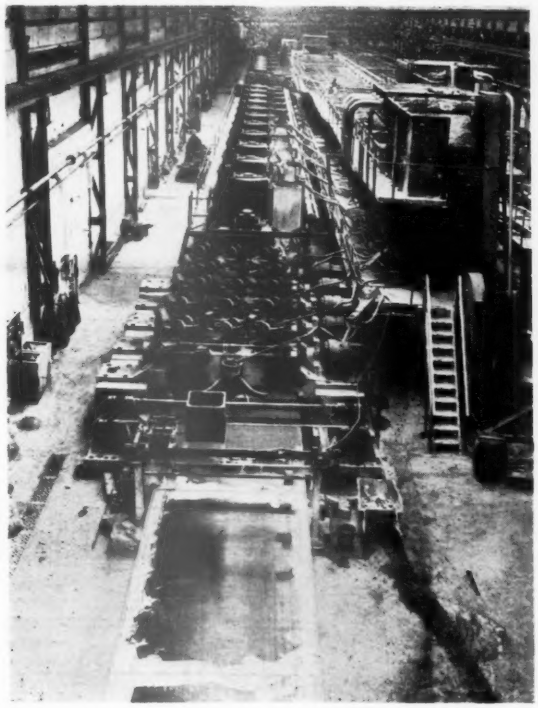


Fig. 6
Grinding and polishing machine

commercial scale were devoted to this product. But rolled glass, with its obscured and patterned surfaces, does not call for the standards of glass quality demanded by polished plate glass, and it was a year or two before this was achieved by suitable design and operation of a manufacturing unit consisting of continuous furnace, rolling apparatus and annealing lehr delivering a continuous ribbon of rough cast plate glass which, after grinding and polishing, proved to be of excellent quality and uniform thickness. This was revolution No. 1. (Fig. 5.)

Simultaneously with the development of continuous casting, work was proceeding on a grinding and polishing machine with many of the features of a continuous process. This machine in its latest form (Fig. 6) consists of a travelling table, 650 feet long, made up of a succession of cast iron slabs constructed

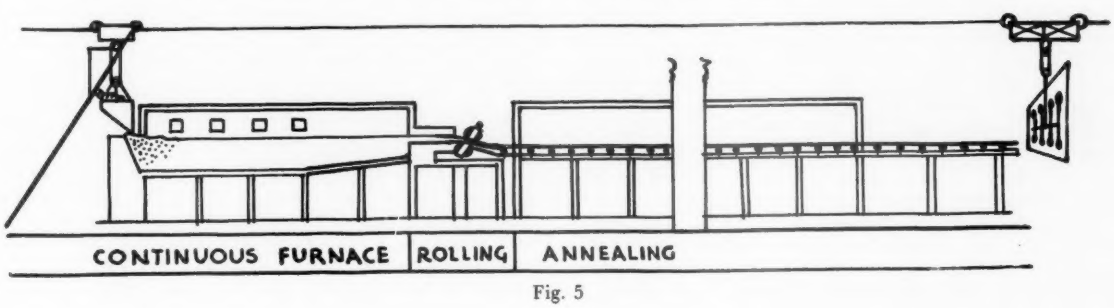


Fig. 5

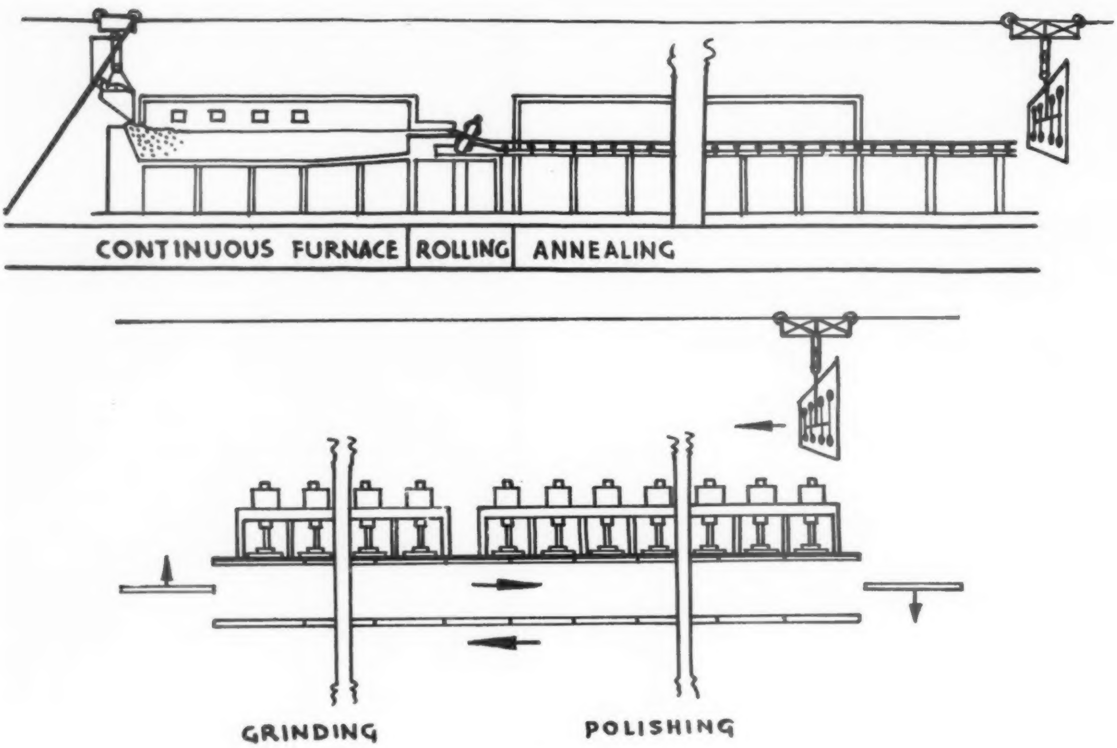


Fig 7

with great accuracy and coupled together to form a level platform of the right width to take glass plates cut from the rough cast ribbon, so that, in effect, there is a continuous glass surface. This passes under a succession of revolving iron runners fed, as in the case of the circular grinding machine, with progressively finer grades of sand followed by a similar arrangement of felt polishing runners fed with rouge. At the end of the machine, the glass plates, polished on one side, are lifted and transported to the beginning again to be relaid, and their other surfaces ground and polished. This was revolution No. 2. (Fig. 7.)

The " Twin " Process

Revolution No. 3 was to follow about fifteen years later. In the interval, much thought and experimental work had been devoted to the possibility of grinding simultaneously both surfaces of the travelling ribbon, while still in the form of a continuous ribbon, and in 1937 my Company brought into successful production the first full-size commercial unit consisting of continuous furnace, rolling machinery, lehr and grinding machine. By this date, therefore, manufacture of plate glass by what, in the fullest sense of the term, could be called a continuous process up to the end of the grinding stage, had been achieved; in addition the combination now operates successfully on an output which, in consequence of relatively minor adjustments, is at least three times that for which it was originally designed. Due to this and to the expansion of manufacturing capacity, all ordinary plate glass produced in this country, as distinct from the considerable amount of special types or thicknesses, is now made by this twin process (Figs. 8 and 9).

The " Twin " even now requires a plant nearly 1,300 feet in length, and as a straight engineering problem you will understand that it is not easy to keep a continuous ribbon of glass, a hundred inches wide but only a quarter of an inch thick, subject to great pressure and many stresses, so straight and uniform that it does not wander a quarter of an inch in the course of nearly a quarter of a mile.

It was originally designed to do the polishing on the same ribbon and in the same way, and for a time this was done : the wartime increase in output, and therefore in speed, from the tank and through the lehr was, however, such that more grinding heads became necessary and in the space available this was done at the expense of the polisher and the glass is now polished subsequently on a separate high-speed polisher, one side at a time. This, on our scale of operation, is not, as might appear, a step backwards. There are three main reasons why this is so—first, the increase in capital cost of making the building and equipment for a ribbon, say 2,000 feet long, so that on our estimates the saving in cost might be more than eaten up by capital charges; second, the greater likelihood of breakage at the polishing stage and the

consequential damage caused by more scratches to glass following the breakage; and thirdly, that the possibility of taking advantage of sudden technical progress in any one sector of this continuous line may be limited if others cannot match it, and being at the end of the line the polishing is the most likely to limit advance in any of the other sectors.

Although, therefore, if we were starting a new plate glass works completely afresh in a flat open space we would think again very carefully before omitting the Twin Polisher, and although we would certainly leave room for its later adoption, at present on existing plants its advantages are outweighed by its disadvantages, including overall cost.

The production line therefore is now as shown in Fig. 10.

To complete the manufacturing picture, large rectangular plates, after polishing, pass through a washing machine and go into the warehouse where each is placed vertically in a frame which can be raised or lowered at will. The glass, illuminated by special lighting, is then examined for manufacturing faults which are marked on the surface by the examiner. He is followed by one known as the " marker " who, with the faults before him and a comprehensive knowledge of the sizes called for by the orders, decides how the plate can be cut with least loss of glass and indicates his decision in writing on the plate. This is now transferred to a horizontal table where it is divided up by the cutter in accordance with the marker's instructions, after which the cut plates are finally checked for size and quality before going for packing.

I hope that this account has enabled you to form, in outline, a picture, not only of how our plate glass is made, but of how the methods in use to-day have been developed over the last few decades. To you, as Production Engineers familiar with modern trends throughout industry generally, the economic significance of each step forward will be apparent and it can be shown that the advantages gained have been very real.

Let me give you a few examples. In the first, the modern trend of making molten glass and casting a continuous ribbon is compared with the old pot process producing individual plates. The two variables of greatest significance are output per man-hour and per lb. of fuel consumed and in both cases

Fig. 8
Twin grinding and polishing process

they are related to the area of glass delivered ready for grinding and polishing to finish at the same thickness.

	Pot Process	*Ribbon Process*
Square feet Man-hour	1	11.2
Square feet Fuel consumed	1	8.0

The second example compares the three grinding processes, namely :

1. The 36 feet diameter circular table machine
2. The continuous table machine
3. The latest machine in which both surfaces of a continuous ribbon are ground simultaneously and in this example the significant factors are man-hours and consumption of electricity.

	No. 1	*No.* 2	*No.* 3
Square feet Man-hour	1	1.8	10.8
Square feet Electricity	1	2.1	4.0

The third example is on somewhat different lines. In connection with licensing negotiations, it was necessary to make a detailed analysis of the process costs to show how the latest manufacturing unit

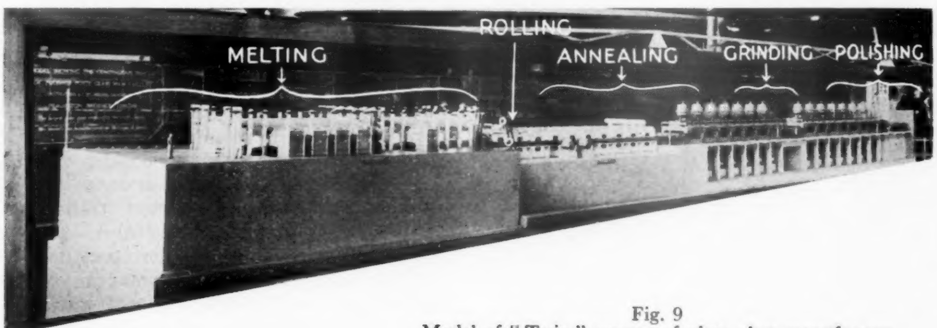


Fig. 9
Model of " Twin " process of plate glass manufacture

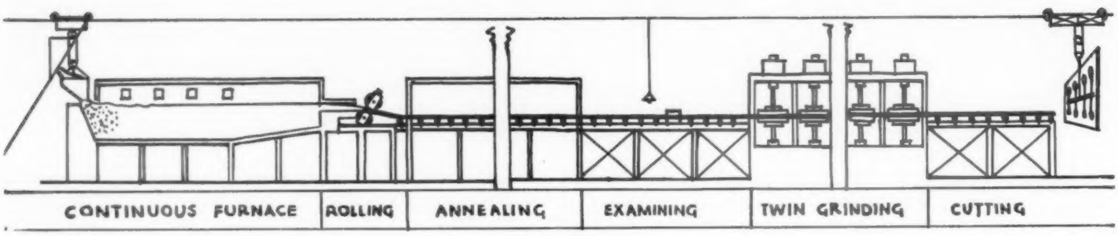


Fig. 10

consisting of continuous furnace, rolling machine, lehr and Twin Grinder (as the machine which grinds both surfaces of the ribbon simultaneously is called) compared with the immediately preceding combination consisting of a similar continuous furnace, rolling machine and lehr but with the corresponding grinding capacity in the form of continuous table machines. This analysis showed that, by comparison with its immediate predecessor, the more modern combination reduced the works cost by 21.4%.

Incidentally, this process, developed in England, has been licensed in U.S.A. where the first plant has just started up and in a number of countries in Europe where it is in commercial operation in France, Belgium, Germany and Italy.

The fourth and last example is based upon a comparison between a complete manufacturing unit of the most modern type and its equivalent capacity in the form of the processes in use just before the First World War. In seeking figures so far back it has been necessary to fill in some gaps from later information on the operation of the older methods, but the comparisons may be regarded as fair and, if anything, conservative.

Year	1913-1914	1953
Square feet / Man-hours	1	7.6
Square feet / Fuel Consumption	1	8.3
Square feet / Electricity Consumption	1	4.5

Effect on the Customer

Finally, as the eventual criterion I think you would be interested to know what all this has meant to the customer, bearing in mind all the time that in 1913 (which we have taken as the starting point) plate glass was by no means a new industry but one that had been established here and on the Continent for a very long time. Here is the price, taking 1913 as 100, of a normal shop window about 10 feet x 7 feet in :—

1913	100
1920	240
1930	145
1938	148
1953	208

I will not elaborate on the comparison between this index and a similar index for the cost of coal or wages, or transport, for the general picture conveyed by such figures is well enough known and will no doubt approximately be present in your minds. But it does show that the benefit of the inventions has been passed on to the customer and that our reward has been the consequent and continuing increase in the use of glass. Another aspect of this, that to Production Engineers I am sure is obvious but none the less important, is that every labour saving device or improvement, every fundamental development, and every reduction in cost, has reduced the number of man-hours required to produce a foot of glass, but it has before very long increased and not reduced the total volume of employment in the industry. The industry has had its ups and downs in employment for other reasons—usually economic factors such as the 1929 slump brought these about, but on balance much more glass has been produced from about the same labour force, rather than the same amount of glass from a smaller labour force.

And now, if we take ourselves back again to thirty-five years ago and re-examine the list of short-comings, we shall find that they have all disappeared. With this state of affairs you may think that one should be well satisfied, but I hope that it won't be thirty-five years before you hear in retrospect of the list of shortcomings as it stands to-day. Let me tell you of one now.

Due to the combined effects of high temperature and chemical attack, the interior areas of a continuous glass-making furnace wear away and at intervals of two years or so, it becomes necessary to put the furnace out of operation for repairs. The stoppage of glass-making, including the rolling and grinding of the ribbon, lasts from six weeks to three months and as it affects a very large proportion of the total manufacturing capacity, the interruption may be regarded as a major disturbance of production.

An obvious necessity accompanying the creation of the large integrated units has therefore been the provision of a large stocking capacity to act as a flywheel, absorbing glass slowly while the unit is in production and releasing it quickly during the stoppages. This is, of course, an undesirable necessity, as not only does it entail additional costs but money is tied up in stocks. Skilled glass-makers have to be found alternative and usually less profitable employment for the duration of the stoppage, and it is not too easy to plan maintenance work throughout the factory in such a way that a staff of tradesmen sufficiently large to deal expeditiously with

very big repairs at infrequent intervals can be kept fully and usefully employed at other times.

Every technical advance brings its own problems and this is admittedly a conspicuous example of those that have accompanied the solution of the large integrated glass-making unit. By comparison, it is a minor problem which may or may not be solved by having two furnaces to each unit and moving one into position for production while the other is moved out for repairs. As a modern continuous plate glass furnace with its contents of molten glass weighs about 7,100 tons, it should provide an interesting exercise for the engineers.

Importance of Quality

I would like now to refer in some detail to an aspect of plate glass manufacture which is of great importance in its effect on productivity. It concerns glass quality and, as a continuing perplexity, it owes its existence to the fact that, stated simply, it is not easy to make good plate glass.

Glassmaking, especially the making and refining of molten glass is not, or at any rate is not yet, an exact science. The sequence of thermal, chemical and physical events inside a continuous furnace is of great complexity and is incompletely understood. The refractory materials of which the furnace is made have been much improved over the last thirty years, but they are still capable of contaminating the molten glass. Minute quantities of some insoluble minerals in a wagon of sand can survive the processes within the furnace and appear as faults in the glass, and since glass is transparent, blemishes in the body of the metal, that have no other significance than that they are visible to the eye of a keen inspector, are not permissible.

In the case of grinding and polishing, the basic principles are more fully understood and surface blemishes can be more easily traced to an identifiable cause but faults of sufficient importance, whether in or on the glass, entail cutting, and cutting imposed by the presence of faults invariably entails wastage of glass.

That the percentage of glass wasted must be very sensitive to the prevalence of defects is almost self-evident. Even if the quality of the large plates entering the warehouse were perfect, some wastage would be inevitable, because the order sizes, in all their variety, would not be a precise match for the glass sizes but, clearly, the larger the glass sizes the lower the wastage. If, on the contrary, the glass sizes become substantially smaller, and it needs only one fault in the middle of a plate to halve its size, the greater the wastage, and it is not difficult to see why wastage, expressed as a percentage, can rise very steeply with quite a small increase in the average number of faults per plate.

When it reaches the warehouse, the finished glass has, of course, borne nearly the whole of the processing costs and a 25% wastage means that four square feet have been made to sell three. It might be argued that this overstates the case because all the wastage goes back into the furnace but, regarded as a raw material, broken glass, or "cullet" as it is called, is no more valuable than frit, the cost of which is very small by comparison with that of the finished product.

Wastage at all stages of manufacture due to faulty glass is, of course, nothing new, but it assumes a much greater importance when it is associated with the output of one of a few large manufacturing units instead of one of a much greater number of small and unintegrated plants. On the other hand, there are, from the standpoints of technical control, compensating advantages in the modern continuous processes in which, after establishing suitable conditions, the aim is to keep these constant in contrast to the old processes where the objective, less easy to achieve, was to control the varying conditions throughout each of a succession of cycles.

Moreover, efforts to achieve better glass for more of the time go on unceasingly. Since the First World War, technical development has been accompanied by a great increase in the number of scientific and technical men engaged in the industry. Research work is providing a better understanding of basic principles and much that was once obscure is now explained. Improved instrumentation has not only made more extensive technical control of the processes possible but it has enabled it to be more precise and more informative. To take just one example, the application of polarised light to the moving rough cast ribbon reveals certain irregularities which, without it, would be quite invisible until the glass had been polished. And as a last reference to the campaign for quality, every plate of glass, with its defects, if any, entering the warehouse can be traced back to the conditions which prevailed at the time at which it passed through any one of the processes in the course of its career.

Keeping the Lead

It must also be plain that successful maintenance of a highly competitive productive industry in this country depends on being technically in the lead; that that lead can be achieved by invention, by imaginative thinking, by team work, as has just been described, by acquiring and improving processes invented by others, by co-operating with others—whether competitors, manufacturers or customers in new methods of manufacture or distribution—and even by acquiring a process and by agreeing to continue to acquire future developments from the same source. All these methods we have tried in one kind of glass or another. What is certain is that inventive genius is not the monopoly of any one nation or firm and that it is essential to preserve an open mind and to use all these methods to keep in the lead.

In plate glass, generally speaking, we have been the inventors and in due course we have made our inventions and knowledge available to others. In sheet glass it so happens that we have more often acquired fundamental inventions under licence from others and have improved upon and developed them; and similarly in many uses of glass, of secondary processes such as the toughening process used for turning plate glass into safety glass.

I do not think, moreover, that there is any one answer as to which of these methods is the more economical. I do not think that in licensing some of our more important processes we have ever recovered fully the cost of development. On the other hand, by developing them we gain a lead and a start on others for the next advance, and we gain additional knowledge that is of great use in the actual operation, and over a wider field. Moreover, firms that do not themselves invent or develop, are likely to find it difficult to obtain other people's inventions indefinitely on reasonable terms.

I think there is one matter that is important in our industry, and in everybody else's, that is worth a reference. That is the very long period between the conception of an invention and the putting of it into commercial use. In the case of the Twin Grinder which I have described, I suppose commercial full scale production first came at least fifteen years after the main outlines were fairly clear in the minds of the inventors. This is partly due to the extreme difficulty in our industry of operating any kind of a production machine on a pilot plant or on an intermittent scale, and this means that unless there are subsequent patents or a great deal of specialised knowledge, the original invention has a very short period of protected full scale commercial operation. However, the fact remains that in the plate glass industry we have, in the case of the Twin, led the world by many years and that even now (some seventeen years after it has been in commercial operation with us as a main process and some thirty years after it was first conceived) we are licensing it to the American manufacturers, and of course our new licencees will be getting a much better plant than we have since it will be built in the light of today's knowledge, whereas we have had to incorporate improvements as we went along.

Future Development

That leads me to say a few words about future lines of development. The ideal time to produce a new invention is as soon as you have exhausted the possibility of licensing the last one and when you have sufficiently written down the tremendous capital involved in the invention to be superseded. It is certainly not economical if inventions supersede inventions so rapidly that there has to be a constant capital loss to be provided for, or if the consumer has to bear an extremely heavy obsolescence charge due to the very short life, but competition does not always let inventive genius conceive and bring forth at the psychological moments.

For some time now the number of fundamental revolutionary developments has been small, but at least equal contributions to productivity have come from the improved operation of existing processes. The Twin has, in fact, operated within the last two or three years at over three times the speed for which it was originally designed, and I think that for some short time further our competitive position may well be kept by continual further refinements and improvements on present processes; refinements that mean constant attention to detail, not only to those parts of our cost that form part of the main manufacturing processes, but to those parts, such as the handling of raw materials, or to the better use of fuel, that come before manufacture, and certainly to those parts such as warehousing and distributing techniques that come after. For the main manufacture, since we are one of the few industries in which the plant already works 168 hours a week and 52 weeks a year, we can only get more from the furnaces by increasing speeds; by increasing the amount of glass that we can make within a given period; by reducing losses; consuming less fuel, less power, and only to a very small degree, less raw materials. I am, however, certain that well within the next ten years we must and will see clearly the shape of further fundamental advances. The problems to be solved are known to us. They are being tackled and by others as well as by us. I hope that we shall again get there first.

Use of Work Study Methods

Perhaps this is a point at which I might say a few words about productivity as between us and the Americans. We have not sent a Productivity Team to the United States and we and our American competitors do not know all each other's secrets, but I am sure that despite the fact that we have constantly led in invention in plate glass, there are some matters in which they lead in cheapness and in satisfying the customer with his requirements, and there are some matters in which they have a definite advantage, and paradoxically enough, one of the most important is that they have the benefits of greater flexibility through possessing smaller units in relation to the size of their market. Their market, with the enormous American motor trade, is so large that they could not possibly supply it from the output of only two tanks as is the case with us. This gives them a much greater opportunity for mass production for individual trades, for example, for the motor trade. They can therefore turn the whole of one furnace on to manufacturing thin plate glass for laminating for motor windscreens; they can make widths suitable for that trade and no other; they can indulge in automatic cutting of the glass for large orders of one size, to a degree that would be quite impossible with our more varied market.

A very great deal of our labour is used in the warehouse, in examining, cutting and packing; as far as we can judge from such employment figures as we see in the United States, the labour force used in plate glass manufacture over there per square foot of output is less than two thirds of our own; with all the valid reasons why this should be so, I am still sure that we are not fully streamlined, or productive, yet. Of course, we have for years tackled this question with the aid of time study and work study methods, and we believe we have got very far in their sensible application; there is further to go, certainly; but in twenty years it has been systematically applied throughout the works—including the control of maintenance—and costs have come down steadily. We know we have certain natural disadvantages and certain other natural advantages;

but we know too that only by getting our productivity up yet further can our plate glass hold its own against competition from low price sheet glass, low labour costs on the Continent, and from American mass production. This cannot be achieved haphazardly: it requires leadership and team work. It is because, throughout this century and before, we have been blessed with men of imagination, vision and drive, real leaders, and with loyalty and team work throughout the factories, that our manufacturing people have been able to give people like me such an easy task in selling plate glass in the markets of the world.

From what has emerged in the course of this Lecture it will be concluded, rightly, that in the search by the glass makers of the world for new and more efficient methods, the plate glass industry in this country has not been at the tail of the procession. In so far as it has led the way, its success has been attributable to the imaginative thinking, perseverance and courage of an ever-growing number of people at all levels working together as a team. In general terms, there are now as many hundreds of scientific and technical people as there were of individuals fifty years ago and while one hesitates to associate with imaginative thinkers what is called, and sometimes miscalled, "organisation", there has to be some sort of orderly framework within which each member of the team will be happy, not only to give of his best but to give it to his fellow workers.

That then describes the manufacture of plate glass and attempts to show that there are plenty of problems for us to look forward to in the future as well, and that we have the will to tackle them, and the men and the experience to give us a chance of success. The eventual criterion of our progress is whether our competitive position in the world has improved, and whether or not we are able to offer better value for money now than we were before these revolutionary changes took place. As to the former, in the 1920's imports of plate glass into Great Britain were twice our exports; now our exports are more than three times as great in volume as then, imports only a third of that level, and exports have been more than double imports every year since the War, and this year will probably be four to five times that level.

Value for money is compounded of price, quality and service. I have shown you that the result of all these developments has been a great reduction in price in comparison with wages and most materials. Quality, too, has improved, so that with an enormous growth in the proportion of high quality glass demanded and a great reduction in the market for the low quality by-product, we have still been able to raise the general standard. Good service has become immeasurably more difficult to give, thanks to these inflexible mass production methods; but it has been maintained, at the cost of carrying much heavier stocks. In total, unquestionably this progress has resulted in the consumer getting much better value for money than ever before, and this tendency we confidently expect will continue in the future.

REPORT AND DISCUSSION

At a General Meeting of the Institution of Production Engineers, held at the University of Leeds on Monday, 9th November, 1953, the first George Bray Memorial Lecture, entitled "the Manufacture of Plate Glass", was presented by Sir Harry Pilkington, Chairman and Managing Director of Pilkington Brothers, Limited, and President of the Federation of British Industries. The President of the Institution, Mr. Walter Puckey, occupied the Chair.

Among the principal guests were Mr. Clifford Bray and Mr. George Bray, in memory of whose father, Colonel George Bray, the Lecture has been established.

Before the Meeting, the President gave a sherry party at the University Staff House, where members of the Yorkshire, Halifax and Sheffield Section Committees, together with leading personalities in the glass industry, were able to meet Sir Harry Pilkington.

The CHAIRMAN, in opening the proceedings, said he felt greatly honoured in being allowed to take the Chair. His temerity in coming to Yorkshire to do so was due solely to the fact that this Lecture must be regarded at a national one, and the platform as a national platform. The Institution were very grateful to the authorities at Leeds University for providing facilities for the Lecture to be given in such a splendid room, and to the Yorkshire Section for their invaluable help in organising the Meeting. It was only right that Leeds should be the venue for what was hoped would be the first of a series of lectures to the memory of a very distinguished man.

A Distinguished Yorkshireman

In 1951 the Council of the Institution was asked by General Appleyard, one of his own predecessors in the office of President—and he was happy to see General Appleyard that evening—to accept a suggestion put forward by Mr. Nurrish, who was at that time President of the Yorkshire Section. He was delighted that Mr. Nurrish also was present and would take the opportunity to say how great a debt was owed to him for his work as President of the Section. The suggestion put forward by Mr. Nurrish at that time was that a fund should be set up to commemorate a distinguished Yorkshireman, Colonel George Bray, who had himself done a great deal for the Institution as well as for the Yorkshire Section of which he was at one time the President.

Sir Harry Pilkington (left) chats with the President of the Institution, Mr. Walter Puckey (centre) and Mr. H. R. Howes, Director of United Glass Bottle Manufacturers Limited, at the sherry party held before the Lecture.

The Council accepted the suggestion, and a donation of £500 was set aside for the purpose of commemorating Colonel Bray's memory in what was to be known as the George Bray Memorial Lecture. The only condition was that the Papers given should, if possible, illustrate the application of production engineering methods to industries not traditionally engineering industries. This was in keeping with the character of George Bray himself and with the width of his outlook. It was also in line with present thought in the Institution. For the last few years, as members would be aware, the Institution had adopted the expression " broadening the base ", and had endeavoured to instil in its own members the importance of broadening their own techniques and imagination, and of embracing in the sphere of production engineering a wider field than that normally covered by what was perhaps their birthplace—the metal-working industries.

It was not his purpose—indeed, it would not be right in the milieu of a professional institution—to dwell in detail on the activities of the company Colonel Bray had headed with such distinction. But it might not be inappropriate to say that, as many members knew, this company was formed ninety years ago and was as modern to-day as ever it had been in its long history.

The Institution had every reason to be grateful for the support given to it by Colonel Bray and his numerous colleagues. They had on all occasions opened their doors willingly to help it. The company was formed originally, he understood, to make gas burners, and it was gratifying to know that their flame was burning brighter than ever. It was to be hoped that light would continue to be thrown for years to come on the memory and achievements of Colonel George Bray.

A Family Tradition

The lecturer, Sir Harry Pilkington, was also a member of a firm with a fine family tradition—a great tradition of workmanship in the service of the community. His subject was well chosen and would undoubtedly have met with the warm approval of Colonel Bray.

The name Pilkington was known in all parts of the world. As Chairman of a great company, Sir Harry was undoubtedly carrying on its traditions worthily. In addition, he was now President of the Federation of British Industries for 1953.

He must be a very modest man. He said in his Paper that he was not an engineer in any shape or form. He could be assured that whatever shape or form he wished to take that evening, the Institution was very much honoured by his presence. He had great pleasure in inviting him to give his Paper on :

" The Manufacture of Plate Glass ".

In presenting his Paper (which appears on pages 7/17). Sir Harry said that it was indeed an honour to be asked to give the first George Bray Memorial Lecture. He intended to assume that those present had read the preprint of the Lecture, and he would therefore enlarge on a few points and then invite questions.

He continued : I have re-read the preprint fairly carefully in order to see what are the more important points which I should bring out in the space of the short time available to me. I hope that one of the impressions it will have left upon you is the enormous scale of the production unit which is required nowadays for the manufacture of plate glass in relation to the cost of the product and the size of the demand. To me this seems fundamental, because so many consequences of all kinds flow from it. It has economic consequences in the market and

method of supply and distribution. It has also consequences for the manufacturers themselves.

A Unique Position

As far as I know, there is no plate glass manufacturer in the world now who makes anything but plate glass out of a plate glass tank. Equally, there is no plate glass manufacturer in the world now who makes plate glass alone. There are plenty of manufacturers who make sheet glass alone or the different kinds of rolled glass and so forth. But there is none that confines himself to the manufacturer of plate glass. That, I think, must be because the scale of the undertaking is so great that you can only have one unit in one works. The chance of keeping that going all the time is nil, or practically nil, when you operate on that scale. You must have something else to balance it. There may be other products in the same position. I do not know. I expect there are, but I do not know of any. Perhaps the Lecture does not bring out fully, therefore, our extreme dependence as a firm or industry on ourselves if we are to keep the lead, a dependence running right through from beginning to end.

We must design plate glass tanks for the furnaces. We must test the refractories and we must even get the machinery made for us. We cannot learn from other people's successes or failures. And it must be remembered that a bad shot—a failure—is very expensive indeed in this industry. It does happen, because you cannot rely, I am glad to say, in modern industry on the "safety first" principle. Having achieved a certain measure of efficiency or perfection with one particular design or one particular unit, you must try to advance. And however much you may try something out in the laboratory or even on a laboratory scale in pilot plants, it is not the same when you come to full production. And when you are dependent on two individual units only for a demand equivalent to that of the whole British Empire you are, as you can see, taking a big risk. You must have already provided some sort of safety margin in the way of supplies.

Relation of Production to Demand

The first point that I want to stress, then, is the enormous scale of production in relation to demand. Perhaps it is worth mentioning at this point also, although I have not stated it in the Paper, that glass is fundamentally made of very cheap materials—sand, lime and soda ash. A great deal of labour and fuel consumption is involved, but the main charge is the capital cost of putting in a completely new plate glass installation. I am quite sure you could not hope to turn over your capital once in two years. Again, I have no doubt that there are other industries in that situation. But it does make one think before starting up. It means that you do not go idly or lightly into a new country nor, in fact, do you get anyone else starting here. This is not because of any particular trade structure or agreement or restrictive practice, but because the chance of building a complete plant with the enormous capital

Among the guests at the sherry party were **Mr. Clifford Bray** and **Mr. George Bray**, sons of the late Colonel Bray, who are here seen talking to **Mr. F. T. Nurrish, M.B.E.**, Past President of the Yorkshire Section and **Managing Director** of George Bray & Co. Ltd.

involved and then selling the output continuously on a 168-hour week basis is really very high and makes people stop to think.

There is another feature of the industry—and I am dealing more with the economic factors, partly because I know more about them and partly because I presume Production Engineers, like anyone else, are willing to talk about economics! I have never found anyone who was not, whereas a lot of people are not prepared to talk about difficult technical processes. As I say, there is another feature of the industry—only in very few countries is plate glass now made for world markets. To make it on a small scale is so costly that it could not possibly compete in world markets. It could, of course, be made on a small scale behind enormous tariffs, but I do not count that. It is a fact that it is only made now in certain countries on the Continent of Europe, in the United States of America and here. In each of these countries it is concentrated in a very few hands.

In referring to that part of the Paper which deals with the basic processes of manufacture, I would only emphasise once again that it is of the utmost importance that each process should be right, because it is linked nowadays to subsequent processes. That, of course, is a common feature of modern industry. For instance, it is of the greatest importance that the batch should be thoroughly and properly mixed and should not then become unmixed.

There have been great developments in the past ten or twenty years in mixing and in the filling of a tank. Instead of filling, as one used to do, thoroughly mixed batches, say a ton at a time, in great lumps, we now feed the mixture by an automatic blanket system, a system which adjusts itself so that all the time, as glass is drawn out at one end of the tank, the equivalent weight of batch goes in at the other end, with the consequence that the level never

varies. This has a great deal to do with the maintenance of a really homogeneous metal, as we call it. I do not like to use the word "metal", because I shall be told that we are an engineering industry, which we are not. But for our purposes we do call glass "metal", and the maintenance of homogeneity is of the greatest importance in glass manufacture.

Troubles in the Tank

A great deal goes on inside the glass tank with a thousand tons of molten metal in it at any one time; and nobody knows very much about it, certainly not the glass manufacturer. Sometimes the sales department think they know, but nobody else does. Our scientific staff know a little more than they used to do about convection currents and what happens with sand and other material going in at one end and coming out at the other. But they do not know all about it, and there is no way of finding out. You cannot get inside a tank at a temperature of 1500° Centigrade. Yet troubles in the tank upset the whole of the subsequent processes, because all the processes are completely linked up nowadays, and therefore it is of the utmost importance to get a homogeneous glass. There is not much difficulty if you are content to spend a very long time in heating it, refining it, keeping it fluid and gradually cooling it and flowing it out in the old way. There are some figures on page 13 of the Paper showing fuel consumption. The relationship is one to eight for the pot process and the ribbon process respectively.

In the old days more than a ton of coal was used for every ton of glass that was made. That is down to well under a third for the actual glass manufacture; but a great deal of fuel is, of course, used later for all the power machinery—for electricity, for grinding and polishing. But in the actual melting of the glass over a ton was used. This has something to do, of course, with the location of the glass industry. I am often asked why it should be centred at St. Helens, and I do not suppose I need tell Production Engineers the reason. But in the early days of the last century, when most of these industries started, St. Helens became the place for glass because it had coal, and coal was the most expensive of all our raw materials. We used such a lot of it and in using it for melting, we sent a lot of it up the chimney. In addition, our other main raw materials were quite close. There was sand within four miles; although it gets a bit further away every year it is still within reasonable distance. Most of our limestone comes from Yorkshire or Buxton, not very far away. It is common enough and is not very difficult to transport. Alkali comes from I.C.I. at Northwich, just over the river, in Cheshire. One hundred years ago chemicals were manufactured at St. Helens itself. In addition, there was a growing Lancashire industrial area, so we had pretty well everything. Some of these factors are less important now. Coal, for one thing, is relatively less important because we use less of it, even though the price is very much higher. It has gone up in price more than proportionately to many other materials, particularly within the last twenty years.

However, if we were starting completely afresh now, we should still say that South-West Lancashire is probably the best place in this country to make sheet glass and also, I think, plate glass which is not quite so dependent on some of these factors.

This is all rather preliminary. We have tried to set out briefly in the Paper the methods of making the different types of glass; and here, perhaps, I might just say a word or two about sheet glass. On page 8 we have described the modern method of making sheet glass. Sheet glass is drawn out of the end of a long continuous furnace, rather like a plate glass furnace but slightly different in shape.

Only thirty-five or forty years ago, it was made in cylinders several feet long, made by blowing with compressed air. This gave a great sheet of glass in the form of a cylinder which had to be split down the centre and flattened, reheated and rubbed with a piece of wood on the end of a pole to flatten it. This process gave way in the early twenties to the cylinder drawn process, which involved drawing up from pots to the great height of thirty or forty feet. The diameter was much greater than the old method and the quality was better. The sheets produced were bigger, and in consequence were much cheaper, but they were still drawn in the shape of cylinders and had to go through a subsequent flattening process.

When, finally, we had installed our last big cylinder furnace, completing the turn-over from the old cylinder blown method, that process itself gave way almost at once to the modern flat drawn process, which completely dispenses with the process of flattening by drawing the glass straight through the tank in the form of a flat sheet vertically.

Rate of Obsolescence

I mention this as being in a sense typical of the enormous rate of obsolescence we have to face in in our industry. Only three years after we had converted from one process to another, we had to consider scrapping the new process and putting in a still newer

Enjoying the party were these three members of the Yorkshire Section Committee, Mr. J. L. Townend (left), Hon. Secretary of the Yorkshire Section, Mr. Walter Armstrong, M.B.E., member of the Papers Committee, and Mr. G. Hayes.

one at what was in those days a very high cost indeed. Of course, we had to do it; otherwise, we should have been driven out of the market by our competitors. Intrinsically, it was bound to be a cheaper process because of the elimination of the flattening part of manufacture, and in theory it is as simple a process of manufacture as one could have.

The same thing applies in other ways. In plate glass we have had to do a great deal of scrapping and there has been much obsolescence in the past twenty or thirty years. In going round the works after an absence of two or three years, a guide would certainly be needed, because it would not be recognised. I know that this is common to many another industry, but it does happen in our industry more than in most.

One of the differences between sheet and plate glass for the purposes of this Paper is that in sheet glass we have not been the fundamental inventors. The cylinder drawn process to which I referred was developed largely in the United States, although we greatly improved it. Three flat drawn processes were invented later, but we did not invent any of them. We waited, I am glad to say, until we knew which was the best process and then acquired it for our country from the Pittsburgh Plate Glass Company in America. We have made that practically standard, and we have as many, or nearly as many, machines for making sheet glass as they have and certainly far more than any other company in the world.

Improvements and Developments

We did not invent them, as I say, but we have made many improvements and developments. We had the wisdom (it was long before my time) to see what other people did first and when they developed a new method, we took it and improved upon it and used it.

In plate glass, on the other hand, we have made several inventions in the last fifty years. In the time of my grandfather the Siemens regenerative furnace was introduced. In this Paper your attention is drawn to three revolutions in plate glass manufacture. These have been two-and-three-quarters invented, one might say, in this country which has therefore consistently kept the lead.

The first one is the flowing of glass continuously from a tank instead of making it in pots discontinuously, moving the pot along and pouring out and casting. That idea was probably in many people's minds, but two of them brought it to the commercial stage simultaneously. One was the Ford Motor Company who had never made glass before. They thought that was the obvious way to do it, and they were right. That is why I say it was two-and-three-quarters ourselves, because they did, as complete novices, make a considerable contribution to the art of glass working.

The other two were the development of a continuous grinding and polishing machine so that one rectangular bit of glass travelled on a moving table under a series of grinding heads and later of polishing heads, having the surface abraded and then polished. This replaced the old system of filling up a round table with all sorts and shapes and sizes of glass and grinding the glass and polishing it until it was smooth. This was a most wasteful process, but nobody had discovered any other way of doing it.

Continuous grinding was a great advance, particularly when linked, as it was in time, with the development of the flow process which we kept secret for many years after we had developed it.

These two processes are now licensed in other countries. I mention particularly that they are licensed in the United States, because we do tend to think in terms of the United States being automatically the inventors and developers of anything mechanical—any really important advance. But it is not always so. Invention is not the monopoly of any one firm. In fact, nowadays, although the original idea may spring into the mind of one person, it is very seldom the work of one individual alone. There is usually team work, even though one person's name rightly appears on the patent specification in the end.

The fact that these were fundamental inventions is, I think, shown by the fact that the flow process was licensed to two leading American manufacturers in about 1937, which would be some ten or twelve years at least—perhaps more—after we had begun to use it as our main commercial process. The continuous grinding and polishing process was licensed more quickly—in three or four years. It was such an obvious advance on anything done before, and in any case it was not being kept secret. These were tremendous revolutions.

The "Twin" Process

Then we come on to the biggest of all—what we know as the "Twin" process. This has begun to operate, under license, in one of the American works within the last two months, after we have had it as our main commercial process for at least sixteen years and, of course, with all these processes there are many years of trial and error and development before they can be used commercially. This is very significant, and there are lessons to be learned from it, one of which is that it pays to lead and that once you are the leader you get a start and you tend to go on being a leader—to go on inventing. Of course, it is expensive. Only one thing is more expensive than leading, and that is not leading. I know that sounds simple, but it is indeed true. The price of leadership in industry is always extremely high, but it is almost always worth paying.

I hope that the methods of manufacture are sufficiently clearly explained in the Paper and that I need not explain them more fully. I know that they are all right, but I do not think I can make them very graphic in talking about them, and perhaps pictures are more clear. I am therefore going to skip that very important section and let you ask as many questions upon it as you like.

When we put down the plant at St. Helens and Doncaster we made provision for a continuous

furnace and for rolling, annealing, inspection, grinding and polishing. The basis of the grinding and polishing is to do both sides simultaneously, so that the glass is virtually untouched by hand from the moment the raw materials go into the furnace until the completely finished article comes out a third of a mile further on. We were then casting at 45 inches a minute. The ribbon was 100 inches wide, and flowed out of the tank at 45 inches a minute. It went through all those processes inevitably at the same speed, because it was one continuous piece of glass.

Increases in Speed

Improvements in the past few years have increased the speed beyond what had been anticipated and in recent times we have been reaching 150 inches a minute. This means that all the processes have not developed to keep pace with this great increase in speed. We have reduced the amount of grinding. In the old days, thirty years ago, we had to take something like 3 millimetres off each side of the glass which we finish about 6.4 millimetres thickness, the thickness of the ordinary shop window or motor trade window. We used to have to cast at about 12 or 13 millimetres and grind all the rest away. Now, by casting a much more even substance with far fewer irregularities, we find we have only to take off something of the order of 1 millimetre or so. In spite of this, there is still a great amount of grinding to be done, and we could not increase from the original speed to the present speed with the same number of grinding units, so we had to lengthen the grinding stage of the process. We therefore—not having room—scrapped the polishing. It might appear to some people that this is a step backwards, but I have set out three reasons why we think it is not. First, there is the increase in capital cost of making the building and equipment for a ribbon, say 2,000 feet long, so that the saving in cost might be more than eaten up by capital charges. Secondly, there is the greater likelihood of breakage at the polishing stage if the glass itself, instead of being supported on solid cast iron tables when it has the polishing applied to it, has to carry its own weight, supported above and below by the polishing heads. Moreover, it is very much more difficult at the polishing stage to get the machine satisfactorily started again and going through the polishing heads if there has once been a breakage. Thirdly, the possibility of taking advantage of sudden technical progress in any sector of this continuous line may be limited if others cannot match it, and being at the end of the line the polishing is the most likely to limit advance in any of the other sectors.

It is perhaps worth adding that, apart from these points, it is in any case necessary to make some provision for finishing glass discontinuously when it is ordinarily made continuously. In fact, we do not like to carry enormous stocks of polished glass because it scratches. You all know that when you buy a motor car you promptly wipe the wind-screen and put a scratch on it and nobody notices it. But if you were to send it to the motor manufacturers in that state in the first instance, back it would come, even if you had sent it to Australia, with a complaint.

The quality needed is very high and in spite of a hard surface on the material it is capable of being damaged. And on the subject of hardness it might interest you to know something about Perspex, a very good plastic material made in flat sheets. Perspex is moulded between formers, and they have to be really hard and smooth if the Perspex is to have a hard and smooth and brilliant surface itself. Nothing has been discovered, in this country or anywhere else, to serve as a former as good as plate glass. We sell large quantities of glass to I.C.I. for use as formers in making this glass substitute. Naturally they make more than one sheet of Perspex to each former, but it is a fact that nothing else—not even stainless steel—has as smooth and bright and tough a surface as glass. At least, nothing else has been discovered yet, not even anything more expensive. I daresay that as glass happens to be fairly cheap they will be content to use it and concentrate on making it last longer and longer, so that they need less and less of it. As I said, some glass will always be made discontinuously in starting up operations or when something comes along or if there is a breakage. There will be bits of glass sheet cut off at one stage or another, and kept in stock in the rough state. If you were entirely dependent on a twin grinder you would not be able to finish off the glass, and it would be wasteful. Even glass that has been slightly damaged can be sent back for further polishing and made saleable. This cannot be done on a twin polisher, because the essence of the machine is that it has a continuous sheet of glass coming out of the furnace and anything else would inevitably not be polished properly on the Twin. Therefore, the possession of polishing capacity unlinked to the Twin is a great advantage.

Losses in Cutting

Another feature of glass manufacture is the loss incurred later on in the process. I believe we have progress to make in cutting and handling and in making our labour more productive in the warehouse. We have reduced the amount of wasteful labour right through the production process up to the time when the glass is in its finished form. It goes to the warehouse and is examined and marked up, and cut to various sizes to meet orders of different sorts out of one uniform width of 100 inches. To make the glass narrower is unproductive, and it cannot be done because that is the width of the machine. As a result, there are a great many people in the warehouse marking and inspecting and cutting and packing, and in general handling the glass. There is inevitably a very big loss of perfectly good glass in the cutting process.

If you look round the streets of Leeds you will see that it is very difficult to fit any normal collection of bits and pieces of glass exactly into a piece 100 inches by 175 inches. You cannot avoid having a loss of 15 to 20 per cent. unless you can get a tremen-

dously large number of orders for very small pieces of about one foot square. You cannot get such orders as a rule, but if you could you would have to make a low price, competitive with sheet glass or other materials for display purposes in show cases, for instance, and so on, where quality is not of the slightest importance. For this part of our sales, we cannot expect an average price equal to our own plate glass costs, and have to sell competitively as a by-product with something which costs very much less to make.

The Maintenance Problem

In a sense, we have always to take that into account in the structure of our sales tariff. We must sell as much as we possibly can of the glass we make. We cannot sell it all in large sizes because of the existence of faults and of a multiplicity of sizes which is required for different parts of the world. There is always a good deal of waste in cutting down to the smaller sizes. We have to sell small pieces below the overall cost and the larger pieces at a correspondingly higher price to give an average reasonable return. Moreover, it is very important in the glass trade that glass shall be able to be delivered and fixed quickly. Stocks must therefore be carried by glass merchants all over the country. They must carry their stocks in fairly large pieces of glass, so that they can cut and handle them themselves. There must therefore be a reasonable margin in the glass tariff so that they can carry stocks and cut to waste, even more so in that they will not have quite the same range of sizes to choose from or the same opportunity to cut to the best advantage.

You will see if you turn to the top of page 15 that we have made a suggestion there. Personally, I do not believe it is a solution but, as I say, I am on the sales side. It is a fact that we have to put out a tank every two or three years for a complete repair lasting two or three months. For that period it is out of use. The life—the campaign—of glass-making tanks has increased greatly during the past twenty or thirty years. It partly depends on refractories, and refractories have been improving. They also constitute one of the biggest risks because of changes in tank design and methods of insulating and so on. Newer and better and more expensive refractories are introduced because the conditions of glass-making become more difficult and impose more of a strain on the refractory blocks. Nothing can do more damage to the quality of glass than for a refractory block to throw off little bits and pieces of insoluble material that is caught up in the glass in the shape of stones. This is important at all times, but it is particularly important for safety glass, which is a tempered glass cut to size and heat treated—heated up and suddenly cooled to put it into the proper condition. Little bits of stone from the refractories, many of them almost invisible to the naked eye, will almost certainly cause the glass to break spontaneously and very soon. The importance of refractories increases every month.

For that reason and also because of the great loss involved in having a tank out of action for two or three months for repair at the end of every campaign, very great difficulties are involved.

Great progress has been made but a great deal more is needed. It is suggested—and this is a serious suggestion—that one solution might be to place another tank alongside, full of glass-making materials. It would then be moved over by some method, the rest of the machinery being used in the same way as before. The other processes—annealing, grinding and polishing—are more straightforward engineering work. One unit can be taken out—a grinder or roller, for instance—and repaired without upsetting the whole process. Work can even be stopped at the weekend, if necessary, for a few hours to do some really important maintenance. But with the glass-making part itself, you cannot do much of importance without putting out the furnace and cooling it off, and that means two or three months. If there was a spare tank on one side and it was moved over, putting the first tank out on the other side, this might help. I do not myself believe that is an economic proposition, but I may be wrong. It seems to me that the whole tank might be there for three years for the sake of saving three months, and that is disproportionately expensive, particularly as there would have to be a third space for a tank to facilitate this moving about.

The Time Factor

There are many other problems ahead of us. As I have already said, we have to be very much self-contained. We have to design our own machinery and we need a very big drawing office. We have our own engineering shops. We cannot rely on other people to invent glass-making machinery for us, because the market is not big enough. We even have to keep our own tame machinery manufacturers to some extent, not because we like them to make only for us, but because we have to keep them going when we are not wanting these new big plants. Although there is always a certain amount of maintenance work, a new glass plant is not wanted every day.

It happens that there is a spate of work lately, because of licensing for different parts of the world during the last few years and most of the work has, I think, been done by a machinery manufacturer in Belgium with whom we work very closely. But it must be clear that there are not many more people who will be able to install the Twin process.

I have drawn attention to the difference between ourselves and the Americans and have pointed out that one important factor is the very long period between the conception of an invention and the putting of it into commercial use. This may mean that the inventor is worse off than the people who follow later, because after the initial plant is introduced there are an enormous number of improvements. We are going to have increased competition from our American competitors, I am afraid. We have been selling a great deal of glass on the American market during the past few years, and we want to go on

doing so. But we shall find it more difficult when they make glass by our methods than we have done while they were making it by their own.

You may remember, those of you who are old enough, that at Wembley in 1925 we were able to show the window of the Empire, as we called it—the largest piece of plate glass in the world at that time. It was 288 inches by 168 inches—336 square feet. We could not make that particular size now, because we could no longer produce anything as wide. But at the Festival of Britain two years ago we again showed a piece of plate glass which was the largest in the world. It was 600 inches long by 100 inches wide—about 416 square feet—quite a bit larger. There was no difficulty in making it. We could have made it much longer, but there was considerable difficulty in handling and transporting it. Now the Americans who have put in a size wider than 100 inches, as have one of the Continental manufacturers, can make something bigger than we can. I do not think there is any particular advantage, because nobody wants it as big. But it is a fact that on these two occasions, when it was worth waving the flag a bit, we were able to make a larger piece of glass than our competitors. Because of improvements in the process of manufacture, that is not the case any longer. We are in competition all the time with the American manufacturers and even more with Continental manufacturers.

Stimulus to Efficiency

We have every possible stimulus to be efficient. We must sell the whole of the output in these plants. We must work 168 hours a week or not at all. Since the demand is very unlikely to be exactly the same as the production from two tanks, one tank must probably be left idle for a few months longer than is necessary after it has been repaired. A tremendous effort is needed to keep the demand right up to our capacity, and anything we can do to this end is worth doing. We have, therefore, as I say, every stimulus to efficiency.

We have, I think, applied production engineering methods, whatever they may be, pretty thoroughly, but we have still further to go, and above all at the latter end of the process. On that general theme, I will say only this. It is my impression that in very many industries there is much that is common in handling and packing and despatching. That is where there is much to be done in finding out how factories and people in other industries solve their own problems. We have a tremendous amount to learn, but it is always helpful to see how other people solve their problems. In general, I believe we have still furthest to go in handling, packaging and so on in the warehouses.

DISCUSSION

The CHAIRMAN said that the preprint of the Lecture was most fascinating, and he had read it, as he felt sure had many other people, with great interest.

The many engineers who were present must have been interested to hear Sir Harry say that glass manufacture was not an engineering industry. It was not, of course, and there was an essential difference between the glass and the engineering industries. In the glass industry, according to Sir Harry, the capital cost of the plant was high and the raw materials were cheap. In engineering, the situation was that the capital cost was high and the materials were very expensive. In some ways, this made the engineering job more difficult, but he did not propose to go into this question at the moment.

There was an analogy between the contribution towards progress which could be made by glass manufacturers and production engineers. They had four or five factors in common. For example, the design of plant must obviously be the concern of all who were engaged in any form of industry. There were certain basic principles which had to be borne in mind. There was materials handling, and Sir Harry no doubt knew that this had been in the minds of production engineers for a number of years. He had pointed out that it was a major problem in his own industry. Then there was production flow, and who better than production engineers could appreciate its importance? There was quality control, and although one could see the difficulties the fact remained that an industry which had to reject 25 to 30 per cent. of the product had a long way to go. There were many intangibles left that still made life worth living.

Sir Harry had referred only a few minutes ago to the importance of speeding up new ideas so that they came into use more quickly. The Institution had been concerned in recent years that the many original ideas which emerged in this country should be realised in production much more quickly than had generally been the case in the past.

If he might say so, Sir Harry had justified, if justification were necessary, the choice of the subject and the choice of the lecturer. There was much common ground between the glass manufacturer and the production engineer and no doubt the discussion would be more than usually interesting.

Professor H. MOORE, *Department of Glass Technology, University of Sheffield,* who opened the discussion, said that he proposed to start with a definition that might not be very palatable. It was a quotation attributed to Whitworth himself, who said, " Engineering is the dirty work of science ". This might sound somewhat invidious, but engineer-

ing was certainly the medium through which science and knowledge (which might be laboratory knowledge or merely experience in a works) was brought to fruition to the benefit of all mankind. That was why engineering was, so to speak, the foundation or basis of all commercial growth and development.

Sir Harry had, perhaps, belittled his own knowledge in speaking of being on the sales side.

Plate glass and sheet glass had to be quality glass. Although one might put up with half-a-dozen small bubbles in a bottle, if there was a single bubble in 100 square feet of plate glass, or so much as a scratch on it, the architect to whom it was offered for windows would reject it. The fact that ten minutes later it might be cleaned with a gritty duster did not matter at all. It had to be quality glass when supplied, and for quality and price one required absolute control from one end to the other. This was true, of course, of all sections of the glass industry, particularly window glass which people tended to look *at* instead of through!

There were many points of interest in connection with the Twin grinder. He used to go to Pilkington's in 1922 when the whole of the plate glass was made by casting individual pots, rolling them, and putting them through a lehr as an entirely discontinuous process. When he joined them in 1937 the continuous grinder had been developed, and the new Twin grinder was in process of development.

Although Sir Harry had mentioned this as being an interesting development, he himself could think of a hundred little details of processing which were vital to success. Not least, for instance, was the feeding of the glass up through the hollow spindle of the bottom grinder and distributing the grinding material, sand, evenly all over the top surface of the runner that ground the under-surface of the glass. If he remembered rightly, this was a matter not only for the engineer but also for a physicist with a really good engineering training. In a little letter of about five hundred words, not more, the physicist put forward the theoretical work which enabled the problem to be solved.

This was one of the jobs he himself had had to calculate when he first started at Pilkington's, before he had a laboratory or even a room of his own, and there were a hundred other little engineering details where production engineering had to be brought in from the start in order to solve the problems incidental to the main purpose of that development.

He dared not mention the cost of the development itself. The cost of making up the first experimental plant was considerable. It was certainly more than 3½d.! When the final big machine—the production machine—was introduced, he was not shown it until General Weeks, then Colonel Weeks, came up and asked Mr. Scott, the manager of Plate Works, if he (Dr. Moore) had been shown the Twin. Mr. Scott said that he had not, so General Weeks said they would meet at the end of the Twin and go up together. A lot of money was involved and there was some extremely good engineering built into the Twin.

In the making of glass, and particularly plate glass, the job of the engineer was vital to the production of a very necessary commodity. It was in every sense suitable, therefore, that Sir Harry Pilkington should have been asked to lecture on it. Of all the industries he himself knew, apart from the engineering industries, there was none where the problems presented to the production engineer were more difficult or more widespread. The parallel between the glass industry and other industries was very close. For instance, it was amazing how closely paper board manufacture resembled the production of plate glass, though with one important difference. The work was done at ordinary temperatures of, say 50° Centigrade at the outside, whereas with glass the temperature was 1500° Centigrade.

A brief calculation would give some idea of the precision which was required. Something had been said about the length of the continuous ribbon of glass. If there was a difference of 1° Centigrade (not Fahrenheit, it should be noted) between one side of the ribbon and the other as it went down the lehr for annealing, this would produce a deviation of 5 inches in 100 feet. The ribbon was much longer than 100 feet. Provision was made for the glass ribbon to move 3 inches either way from the centre, but in going through the plant at different times when he had been at Pilkington's (a very happy time for him), he had never seen it 3 inches from its centre or any thing like that. There had been some difficulty with the original plant because the lehr was exposed to the open air, but that had been overcome. The difference of one degree across a ribbon about 100 inches wide would cause a displacement of 5 inches in 100 feet, but it would increase, of course, in proportion to the square of the length. This gave some idea of the precision of the thermal control, quite apart from the ordinary production engineering side of the work, that was required in dealing with problems such as were involved in the production of plate glass.

As had been pointed out, the production of plate glass in this country—that was to say, at Pilkington's—had led the world for the last fifty years. He did not know anything about it except what he had been told, but he did know that the Americans had consistently bought a process as it was developed by Pilkington's. During the War a certain gentleman in Germany insisted that a plate glass plant should be put up—without licence, of course—to make glass by the Twin process. The construction was allowed to go on until it was nearly ready for production. Then a number of young men (he did not know that his own son was among them, but at any rate he was in the same lot of people) bombed it and destroyed that gentleman's hope of making glass by the really first-class method that had been developed in this country by Messrs. Pilkington Brothers.

Professor Moore ended by saying that he knew about these things because he had been in the business. What he had said did not, perhaps, contribute much in the way of discussion, but he hoped that it

would have indicated, to a very small extent, the type of control that was required in the glass industry, in particular, plate glass.

Mr. R. L. PAICE, *Director and Sales Manager, Igranic Electric Co.,* said that one had heard in the past of considerable fortunes being made from the reclamation of steel, copper and so forth. Nothing of the kind had been heard about glass, but there must be a tremendous amount of broken glass in the country. Was there any way of collecting it nationally and using it again? Presumably most of Pilkington's scrap went back into the furnace but what about all the scrap about the country? Could it be used in any way? Scrap constituted quite a big business in the engineering industries, and he wondered whether it was the same in the glass industry.

Sir HARRY PILKINGTON, in reply, said that they did use their own scrap, but they did not grind and polish it before working it because this was expensive. They needed to know what they were putting in the furnace and they would not like to use a combination of half-a-dozen bottlemakers' materials with quite different compositions. There were markets for scrap and there were people who collected and sold it at a fair price, a very low price, to glass makers. But quality glass makers had to be very careful indeed about anything that they bought for this purpose.

Mr. H. W. HOWES, *Director, United Glass Bottle Manufacturers, Ltd.*, said that as a member of a company making bottles, jars, pots and domestic glassware he would like to thank Sir Harry Pilkington for his lucid lecture and to congratulate both Sir Harry and his company on the very successful pioneer and development work they had carried out in the making of plate glass.

His own industry used very many processes in common with the plate glass industry. They had similar materials and they melted in continuous furnaces. To a very large extent they moulded or shaped the glass fully mechanically. That was to say, the greater proportion was now moulded in that way. Some companies making small quantities of special bottles still used hand or semi-automatic processes, but by and large the glass container industry was now somewhat similar to the industry just described —completely mechanical, right from the time the raw materials were mixed until the finished product came off cooled and annealed. There was one tremendous advantage, however; it was not necessary to handle vast areas of continuously moving plate glass. When the glass came out of the furnace it was handled in what might be called discrete portions of predetermined weight.

Against nearly all advantages in life and certainly in glass works, there were disadvantages to balance against them, and in this case it was the enormous range of sizes, shapes and detailed specifications. For instance, containers in these days must fit a variety of closures within limits measured in thousandths of an inch internally and externally. Apart from forming these various types of articles, machinery had had to be developed to handle all of them in individual succession at high speed.

Comparing the history of his own branch of the glass industry with that of plate glass, he said that the fundamental ideas did in fact very often come from this country. Many of them, indeed, came from this very county of Yorkshire, going back to the 1870's and from then on. But often the bringing of these ideas into fruition in commercial production was left to the United States. He mentioned this particularly in commenting on Sir Harry's Lecture because it did show how much this country was indebted to Messrs. Pilkington Brothers, who had so successfully led the world.

As with plate glass, mechanical and fully automatic production of glass containers had led to reduced costs and improved quality. The glass container made now, as compared with the time of the 1914/18 War, was an article of precision, both in regard to external dimensions and capacity. In spite of what a previous speaker had said, the industry was not allowed to sell containers with bubbles or scratches. In fact, people wanted a good looking as well as a very close engineering job at the price of something turned out by mass production.

Advances in mechanisation, the speeding up of production, and so on had largely been of benefit, as in the case of plate glass, to the ultimate consumer. He said this to them as production engineers; he was not trying to sell the industry. The increase in price since before the War was modest as compared with the increased cost of fuel, whether in the form of coal, oil, electricity, and so on, and of labour and raw materials.

The very fact of not having one continuous sheet meant that it had been possible to develop a variety of machines, and a multiplicity of furnaces and factories. Over the years these plans had been improved and speeded up, so that they were now not very recognisable as compared with the plants existing when the plate glass industry took a step forward just prior to and about the time of the 1914/18 War.

Mr. A. HASLAM WOOD, *Managing Director, Wood Brothers Glass Co. Ltd.,* thanked the Institution for giving him the opportunity to attend the meeting. As a glass manufacturer, he said, the engineering side interested him more than the academic and scientific side. He was trying to run a very old family business of 125 years' standing in Barnsley, Yorkshire; and there was no doubt that the glass industry, which was so mysterious and intriguing, was a very difficult one to run. Perhaps this was why the glass industry often ran in very old family businesses. The Pilkington family was an example and he himself was another. There was also Bentson and Clark which had run for two hundred years in Yorkshire as a family business. There must be something in it other than the making and losing of fortunes! The trouble was that everything made in the industry could be seen through, which was not always the case in other industries!

In Mr. Haslam Wood's time, the glass industry had gone through two big reforms. In the First World War it went through a scientific reform. His father helped to form the Society of Glass Technology at Sheffield with which, he believed, Leeds University was closely associated. This was essential because of the definitely scientific reform. In the last War, the industry had experienced a very big mechanical engineering reform and this was still going on.

He was referring to the more ordinary glass industry, the bottle glass manufacturers, rather than to the big plate manufacturers. His branch of the industry made what were called odds and ends, all the things people could not be bothered to make, or said they could not. This was fortunate, because occasionally they could ask what price they liked—and extraordinarily enough they sometimes got it!

Not being a scientist, Mr. Haslam Wood felt that the less one knew about the scientific side the better. The side he felt was very important was the engineering side. Glass melting was simple if rightly controlled. The melted product had to be handled and the engineering side became very important. If he were choosing a successor, it would be an engineer, for engineers would be the key men of the glass industry in the future.

There was so much that engineering could do for the industry, not only in handling the raw material before it was melted, but in the formation of the glass and the reaction of metals—the steels and the irons—that were used for making the tools. The tooling up of the machines was of the greatest importance, particularly in the specialised form of the industry with which his own firm was concerned. The kind of metal that had to be used was of more importance in the pressing of glass than in the blowing of glass. In blowing, there was slight pressure on the actual metal, but in pressing the actual surface of the steel of the mould was reproduced on to the surface of the glass. Tools were now even chromium plated after every shift in order to produce the quality headlights demanded by the motor car industry.

One thing worried him. A great percentage of the machines used by the common bottle manufacturers were of American manufacture. It was a crying shame that the British engineering industry did not develop them to look after the glass industry better.

It was a great honour to have Sir Harry Pilkington at the meeting and it was good to know that he, the head of a family concern, with his wonderful experience as a practical manufacturer, should be President of the Federation of British Industries. He hoped the Federation would be run by Sir Harry in such a way as to prevent that mysterious mechanism called government from running them all.

Mr. H. GIBSON, Member, said that he had been many years in India and during the last two or three years he had passed the new factory Pilkington Brothers were putting up at Chattapahar, near Asansol. He presumed it was not going to make plate glass because of the space it occupied. What interested him, however, was the reason why it was put in that particular place. Admittedly, it was on the coalfields, but presumably what was wanted was Jheria coal, which was about one hundred miles away. It would have seemed better to keep to the western edge of the coalfields which would be much nearer to the limestone. The only thing he could think of was the possibility of using Damodar sand, which he hardly thought would be suitable.

Sir Harry PILKINGTON said the reason was not that suggested by Mr. Gibson. Some people from this country had started the works and had not been able to see it through. Pilkington's had come to the rescue. The factory was already partly built, and he did not think his Company would have chosen that site.

As far as plate glass was concerned, he did not think it would be made in India in his lifetime, or even in that of Mr. Gibson.

Mr. H. C. RANDS, *Taylor, Taylor & Hobson Ltd.*, observed that his turn had come rather late in the programme, and that there was very little for him to say after Professor Moore, Mr. Howes and Mr. Haslam Wood.

He did not know much about plate glass, but he did know something about Pilkingtons, and had visited their works on several occasions.

His own connection with the glass trade was in optical glass. Sir Harry, and his colleagues in the plate glass industry, had the advantage of making one type of glass by the mile in ribbon form, and they did it very well. It had been his own job to make a few tons a year in about ninety different types at a small works started by Mr. Haslam Wood's father, in whose service he had been for some years.

Mr. Rands said he must congratulate Sir Harry on his excellent outline of modern plate glass manufacture, and Pilkington Brothers as a firm on the magnificent job they had done in developing a completely continuous process from the melting of the raw materials to the finally polished plate ready for use, except for final inspection and cutting to size.

What happened in a glass furnace was mysterious to the layman, and perhaps not quite understood even by those responsible for melting the mixture—they were sometimes unpleasantly surprised at what a furnace could produce. They were then faced with the task of making modifications to ensure that good quality glass would be continuously delivered by the furnace at a suitable rate for very long periods. The physical properties of this glass had to be taken into consideration in the design of the rest of the plant, and at every stage one could imagine some of the difficulties met with, not the least being that of maintaining the correct supply of abrasive to the under surface of the ribbon of glass.

These various problems were not to be treated separately, but solved simultaneously to suit the general conditions of the whole continuous process.

In his Lecture Sir Harry had summed up the position admirably, when he referred to imaginative

thinking, perseverance and courage of people at all levels working as a team. The various problems referred to were matters for the specialist members of the team, but to win, a team needs a good leader. Messrs. Pilkingtons had for many years had very good leaders, and it was due to them, as well as to the excellent staff they had got together, that the firm had been so successful. The figures given in the Lecture showed how successful!

Professor Moore had mentioned the inspection of plate glass, comparing plate glass with bottle glass as regards freedom from bubbles. He would remind Mr. Howes that U.G.B. did not grind and polish their bottles. If they did they would probably find the bubbles were there!

Mr. Rands explained that he could speak from experience of the skill of the examiners at Doncaster, and was amazed at the high standard of quality insisted on for glass intended for glazing purposes. For glass for mirrors a still higher standard (as regards freedom from bubbles) was adopted. Hence the relatively high price of mirror glass.

He concluded by again thanking Sir Harry Pilkington for his interesting account of Messrs. Pilkington Brothers' wonderful achievement.

The CHAIRMAN said that Mr. Mustill had had to leave, but a contribution from him would be read by Mr. Townend.

Mr. J. L. TOWNEND, speaking on behalf of Mr. C. W. MUSTILL, *Managing Director of Jackson Boilers, Ltd.*, and a Past President of the Yorkshire Section, said that the presentation of a George Bray Memorial Lecture must always be an important event in the history of the Institution for two reasons. Firstly, it commemorated the memory of a great gentleman and a beloved personality, the late Colonel George Bray, who would never be forgotten by those who were privileged to know him. Secondly, care would always be taken by the Council to invite only distinguished persons to deliver the Lecture.

No more fitting choice could have been made than Sir Harry Pilkington, whose Paper had been listened to with keen interest.

In his introduction, Sir Harry had stated that he would not give a highly technical lecture; this self-imposed limitation had been an advantage. The engineer sometimes confined himself too much to purely technical features, with a possible tendency to overlook those commercial considerations which were essential for ultimate success.

On the contrary, Sir Harry had stressed how commercial pressure in the form of competition from sheet glass had been a continual incentive to technological progress in the manufacture of plate glass. In a world in which competition was ever increasing, the general truth behind this statement applied to many industries other than the one described in the Paper.

The choice of subject was a particularly happy one, for there was often a tendency to assume that the production engineer dealt only with metals. It was a good thing to be reminded that the manufacture and manipulation of materials such as glass, earthenware and chemicals called for the exercise of a high standard of production engineering in the truest and widest sense of the word.

When considering the actual process of manufacture of plate glass, it was particularly interesting to note the important part played by the marker, who was required to exercise his skill and knowledge in deciding how the plate could best be cut to eliminate the faults noted by the examiner, whilst at the same time reducing the loss of glass to the minimum. This was another example of another truism so often overlooked: that even in mass production or a continuous flow process, there was still the vital need for the skill of the human operative.

There was only one point in the whole Lecture on which he ventured to differ somewhat from Sir Harry. He referred to "the very long period between the conception of an invention and the putting of it into commercial use". Might he suggest that this long period did not always occur? Surely the length of time between the idea and its actual use often depended largely on the intensity of the demand for the product or process in question. Wartime conditions provided many examples of a comparatively short period elapsing between the conception of an idea and its actual application on a wide scale.

The lecturer rightly emphasised the need to preserve an open mind, as inventive genius was not the monopoly of any one nation or firm. In the past, the mistake had frequently been made in this country of underestimating the potentialities and abilities of nations considered to be technically inferior. It was true to say that during the War this country had received many rude shocks through underestimating the technological ability of the Japanese, whilst the events of the last few years had shown that in many respects Russian technology was much in advance of what was originally thought likely. In this connection, whilst this country could obviously profit a great deal from the vast experience of the United States of America, the lessons to be learnt from a study of the technique of the smaller nations, such as the Swiss whose methods were in some respects more readily adaptable to this country than those of American mass production, should not be overlooked.

The Lecture was particularly interesting as dealing with one of the few industries in which this country manufactured on the same scale as the Americans. In such circumstances, it was rather disquieting to read that the labour force required per square foot of plate glass made in the U.S.A. was less than two-thirds of that required in this country. As the Anglo-American Productivity Reports had shown, a similar ratio applied in many other industries. Whatever the reasons, it was vital to the nation that this state of affairs should be remedied.

The importance of the last part of Sir Harry's Paper could not be over-emphasised, for in it he

postulated the only way in which this country could hope to maintain its traditional place in the world. In his own admirable words, "success has been attributable to the imaginative thinking, perseverance and courage of an ever-growing number of people at all levels working together as a team". The future of the nation depended on the speed with which this conception of industry could be fully implemented.

The CHAIRMAN said that he did not propose to sum up the discussion, but one or two points were worth repeating. First of all, reference had been made by several speakers — more particularly, Professor Moore—to the engineering content of the Lecture. He could not help feeling that on balance the engineers had had it. In saying that, he meant that the engineers had had the greatest support as against Sir Harry's own view that glass manufacture was not an engineering industry. Perhaps the two points of view were not incompatible; but the fact remained that there was proof of the tremendous engineering content of the industry.

It was interesting to hear Professor Moore's definition which attempted to show that an engineering background was essential. He was reminded of a quotation which he might paraphrase by saying that an engineer was a glass technologist who had completed his education!

Sir Harry had taken pains to point out a number of features which it was essential to bear clearly in mind. There appeared to be, in the plate glass industry at any rate, a tremendous outlay of time and money, and the statistics were impressive. The apparent reduction in competition was also interesting. It had come, it would seem, in two ways —by improving the product and increasing the size of the plant to a stage where very few people could afford it, and the more negative way of letting them get to the stage where the plant was nearly complete and then bombing it. But that, perhaps, was rather a special case!

To turn to the commercial aspect, one could not help feeling that in some ways Sir Harry's firm were lucky in the sense that they appeared to have so few competitors. He was in the happy position of being able to state with great clarity and forcefulness that there would not be a plate glass industry in India!

On the other hand, one was led to the view that competition still paradoxically played a very important part in the plate glass industry, as Sir Harry had pointed out on more than one occasion both in his Paper and in his introduction that evening. Competition had forced his company to do certain things, even to scrap plant that had not been fully exploited, in an attempt to keep up-to-date with those who had better ideas.

Indeed, it was only right that the President of the Federation of British Industries should be a man willing to face up to any sort of competition that came along. Sir Harry and his firm represented the true traditions of British competition and quality. Sir Harry was a man, as Mr. Mustill had said, in whom one could place the utmost trust.

The achievements of Pilkington's had been very great indeed. It was marvellous to hear Professor Moore talk about the degree of precision in control— 1° Centigrade over such a length—and the means of checking it. This made one feel that there was a great deal about control in the glass industry that might well be emulated in the metal-working industries. He himself was very much impressed with the whole process of control which appeared to be necessary in this great industry.

As far as he could see, so vast an outlay on plant must mean continuous markets, and he did not think there was any need for Sir Harry to apologise for or make the point that he was not an engineer or not a technical man. The commercial aspect of the business was undoubtedly of the utmost importance if this vast outlay was to be justified. He was reminded of an advertisement he had seen recently, according to which the glass industry was solving an office problem. The busy executive need no longer be bothered by the members of his staff putting their heads round the door to see whether he was free. He could have a glass door. This was an advertisement of a well known firm whose head was not a thousand miles away, and this relatively new development was fascinating. In reading it he could not help feeling that there were considerable possibilities here which had not escaped the attention of Sir Harry and his colleagues. He referred, of course, to those delightful mirrors one saw at the seaside where, no doubt, all Sir Harry's rejects went. One saw oneself reflected in the most peculiar shapes. One could imagine the small dumpy executive or the tall very thin executive saying to Pilkington's, "I want to order some glass so that my people and my visitors will see me as a tall, handsome well-balanced man when they look through my office door before opening it." There were many possibilities, but he would not make any charge to Sir Harry for the suggestion. It might be an idea to have an office door of glass, indeed a whole office of glass, so that people did not have to bother to see whether one was there. They looked and immediately went away somewhere else. It reminded him of the old saying that those who lived in glass houses should take frequent hot baths!

The Lecture had been tremendously interesting and he personally had derived much benefit from it. He would call upon Mr. S. G. Haithwaite to propose an official vote of thanks.

Mr. S. G. HAITHWAITE, President of the Yorkshire Section, said that it was indeed an honour and a privilege to propose a vote of thanks to the lecturer. Sir Harry Pilkington had given a most excellent and informative talk. Those who were present at the Yorkshire Section dinner in April might recall that he himself had made two prophecies on that occasion. The first was that Yorkshire would win the cricket championship. That was very wide of the mark. The second, however, was very accurate: that the 1953/54 Session would be a memorable one for

Yorkshire. Everyone who was present would bear him out on that.

He believed it was true that when one wanted something done, one went to the man who appeared to have the least time in which to do it. In the case in point, Sir Harry controlled a vast glass manufacturing empire and was also President of the Federation of British Industries. Each office was almost a full-time job on its own. Yet he had found time to prepare and present his Paper.

History had been made that evening, in a small way, for this was the first George Bray Memorial Lecture, and Sir Harry had set a very high standard for those who came afterwards.

It had been very interesting to hear about the process by which plate glass was made and if the members of the Institution were invited to go round the factory and see the glass being made, the invitation would be very well received.

In brief, the thanks of everybody who was present went to the lecturer for his very interesting Paper. They all hoped that the company would remain in the forefront of plate glass manufacture.

Mr. G. R. PRYOR, Vice-Chairman of Council, who seconded the motion, said that it had certainly been a red-letter day in the history of the Institution. He was quite sure that everyone who was present would be very glad that he had not missed it. There was an apt quotation from Shakespeare — "And Gentlemen in England now abed, Shall think themselves accurs'd they were not here"!

The Paper was fascinating, but it was rather surprising that what was perhaps the most significant point in the whole of that Paper had not been mentioned in the discussion. A firm of the standing of Pilkington Brothers, which had reached a position in the plate glass industry where it led the world, had the moral courage to take what appeared on paper to be a step backwards. He referred to the abolition of the "Twin" polisher because of other considerations. He was quite sure that this should be a lesson to all of them. Many production engineers gave credence to what was apparently the best thing theoretically and on paper, something—perhaps—which some very large firm had instituted. Such things became shibboleths and needed to be looked at again. By and large, this applied to incentive systems and to costing systems, but this was not the time to go into those questions.

He was very grateful to Sir Harry for making this point so lucidly in his Paper and had very great pleasure in seconding the vote of thanks, which was carried with acclamation.

The proceedings then terminated.

ADVANCER SHORT COURSES IN INDUSTRIAL TECHNOLOGY

The Ministry of Education has drawn the attention of Local Education Authorities, Regional Advisory Councils for Technical Education and Regional Academic Boards to the urgent need to expand the provision of the advanced short courses which enable scientists and technologists in industry to keep abreast of developments and new techniques.

Last year more than 500 of these courses were provided, covering such subjects as recent developments in electronic techniques, principles of mass and flow provision for productive engineering and recent developments in dyestuffs; but the Ministry thinks that the demand for these courses would increase considerably if their existence were more widely known in industry.

It has therefore asked Local Education Authorities, Regional Advisory Councils for Technical Education and Regional Academic Boards to make a special survey of the need for advanced short courses, so that Local Education Authorities and Universities may make additional provision. The Ministry has also arranged to keep a list of all courses and to send particulars of them to the Federation of British Industries and the National Union of Manufacturers, who will inform their constituent bodies.

Employing organisations and individuals are also invited to make suggestions for courses, either to the appropriate Regional Advisory Council or direct to the Ministry (Dept. F.E.1) at Curzon Street, London, W.1. More detailed information about existing, or new, or proposed courses may be obtained from the Secretaries of Regional Advisory Councils.

A.S.T.E. INDUSTRIAL EXPOSITION, 1954

The American Society of Tool Engineers have selected Philadelphia's Convention Center as the site of the 10th biennial Industrial Exposition, which will be held from 26th/30th April. It is announced by the Society that machine tool firms in Britain, France, Italy, Switzerland and West Germany will be exhibiting.

Members who are interested in the Exposition may obtain further particulars from Denham & Company, 925, Book Building, Detroit, 26, Michigan, or from the Secretary, 36, Portman Square, London, W.1.

COURSES IN WORK STUDY

An attractive booklet describing a new series of courses in the technique of Work Study and its use by management has recently been produced by Production-Engineering, Ltd. Copies of the booklet and full particulars of the courses may be obtained from Production-Engineering, Ltd., 28, Bruton Street, London, W.1.

SOME NOTES ON CARBIDE MILLING PRACTICE AT THE SMALL ARMS FACTORY, LITHGOW, N.S.W.

by P. J. W. COTTRELL, B.E., Grad.I.Prod.E.

Production Engineer, Barrel Dept., S.A.F.

This lecture was one of three presented before the Institution of Production Engineers, Sydney Section, at Science House on Tuesday, 4th September, 1951. The other two lectures, which were presented by representatives from Howard Auto Cultivators Ltd., and British Standard Machinery Ltd., dealt with single point carbide tools.

In this lecture an attempt has been made to set out some of the features of multi-point carbide tools based on experiences at the Lithgow Small Arms factory. In Australia this field is relatively undeveloped and Mr. Allan's work in the Bren Gun Section is well ahead of that of most other organisations.

It is considered that the graphical method of cost comparison which was developed provides a very satisfactory method of comparing the merits of high speed steel and carbide milling cutters on any job.

A SHORT summary of the main features which have been brought forward during the use of carbide tipped milling cutters on cast iron and steel components will firstly be presented, followed by a discussion of a number of typical jobs covering set-ups, types of cutter and economics. All descriptions will refer to current practice at the Lithgow Small Arms Factory. In general, the use of carbide cutters has enabled considerably increased production rates and efficiencies. There are, however, limitations and these will be discussed later in terms of production quantities.

Cutter Types

Carbide milling cutters take two main forms :—

1. The first consists of a body of high quality steel shaped to conform to the desired type of attachment of the cutter teeth. The tungsten carbide cutting edges are inserted into slots in this steel body and are held in place by means of a suitable brazing medium. Side and face cutters are normally typical of this class.
2. In the second case, the carbide tips are brazed to shanks in the same way as lathe tools and the shanks are then clamped in slots in the cutter head. This type is very flexible and has the advantage of cheapness of blade replacement and ease of resharpening. It is commonly found on fly and face milling cutters.

The carbide tips are brazed to the steel cutter body with silver solder by means of an oxy-acetylene welding torch. This must be done carefully in order to avoid cracking of the carbide tip, which has a coefficient of thermal expansion about half that of steel.

The success of a milling operation with carbide cutters depends to a great extent on the selection of the proper grade of carbide for the tip. Various grades are supplied by manufacturers, these being designed to meet a wide variety of purposes. Our practice generally follows the grade recommended by the manufacturer for any particular application.

Design Consideration

Before choosing a carbide cutter for any production run, a large number of factors must be considered and a careful analysis of all conditions surrounding the job is required. Typical of these are the material to be milled, the type and condition of the available machines and the available speeds and feeds. All these affect cutter designs.

Some factors influence the kind of carbide to be used, others determine the correct cutting angles. Power requirements in some cases limit the number of teeth.

Problems encountered in the design of carbide milling cutters are generally more difficult than those in the case of corresponding high speed steel cutters. The brittleness of tungsten carbide is a major reason. In addition, the high speeds and high cutting pressures that are usual with carbide milling cutters introduce critical factors that must be considered in order to obtain best results.

Since the transverse rupture strengths of all avail-

able carbide materials for milling are relatively low, ample consideration must be given to the adequate support of carbide tips and especially the cutting edges. The amount of support required depends, of course, on the cutting forces involved. These forces are the product of the machinability of the material being cut and the size of the chip. Hence, carbide milling cutter blanks must be substantial both as to size and strength, so that the carbide tips are rigidly supported in the body.

The blanks must be shaped so that the support extends as close to the cutting edges as possible. This must be done so as to avoid actual body interference with the work, to provide the necessary chip space and to allow a certain amount of clearance between the outer surface of the body and the outer surface of the tip material, so that diamond grinding wheels will not foul the body material when the carbide tip of the cutter is being sharpened.

Complicated cutter profiles are avoided and only simple form cutters are generally made. Two examples will be considered later.

A cutter body blank is selected according to the duty of the cutter. Structural strength must be provided to withstand the driving forces which act through the spindle and cutter body, and are transferred to the cutting edges. In addition, there must be ample mass in the body and it must be sufficiently well distributed to keep deflection at a minimum. It is also desirable that the surfaces of the body should be hard enough to resist abrasion and galling from the chips.

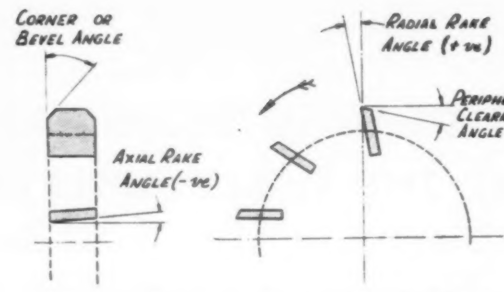
Attention must be given to the size of the hole in the cutter and the diameter of the arbors. In general, it is advantageous to have arbors as large as possible, because of the consequent reduction in torque stresses on arbors, keys, spindles and other machine elements. On the other hand, cutter bodies must be large enough to furnish adequate support for the carbide tips and to allow collars to clear the work piece on slotting and straddle milling operations.

To reduce variations of speed as far as possible the teeth of cutters operating in gangs should be staggered. This keeps the load uniform throughout the spindle revolution.

Cutting Angles

Fig. 1 shows the main angles to be considered on any carbide milling cutter. Recommended values for these angles in machining any particular material are given in various publications. These values are generally used as a starting point and changed as experience on the job dictates. Positive rakes are normally used on cast iron and other soft materials.

In Fig. 1, if suitable values of negative or positive rake are given to the radial and axial rakes, the true rake may be made negative. This means that the initial shock when the tip meets the job being machined will be taken at a point away from the



CRITICAL ANGLES ON CARBIDE TIPPED MILLING CUTTERS

Fig. 1.

cutting edge. Negative rake directs the cutting forces more into the cutter body than does positive rake and takes advantage of the high compressive strength of carbide.

There is a great deal of controversy regarding negative rake cutters. They are used at the Small Arms Factory for many steel milling applications such as fly or face milling. Such cutters stand up longer than positive rake cutters, and give better surface finishes, though their initial power consumption is higher than that for positive rake cutters.

Vibration and Rigidity

Vibration is extremely detrimental to carbides which, because of their low tensile strength, tend to chip easily. Machines on which carbide milling cutters are to be used, as well as all fixtures, should possess maximum rigidity and operate with a minimum of vibration.

Experience has shown that flywheels are effective in damping out chatter and vibrations resulting from changes in load as the individual teeth of the cutter enter and leave the cut. They ensure a considerable improvement in the life of the cutter between regrinds and a better finish on the work. With negative rake milling, flywheels are almost a necessity.

At high speeds it is essential that a carbide milling cutter be well balanced and that the teeth be evenly and accurately spaced around the periphery of the wheel. This ensures that the teeth shall shave the load evenly; a very important factor in high speed milling.

Speed

Suitable values are recommended in various publications and these should be used as the starting point. Normal values are 250—350 s.f.p.m. for cast iron with somewhat lower values for steel. Examples of applications with higher speeds will be discussed later, e.g. in fly milling speeds up to 1,000 s.f.p.m. are frequently employed.

Recent American magazine articles report that considerable success has been achieved with cutting speeds of 1,000 s.f.p.m. to 6,000 s.f.p.m. for carbide milling of steel. Experimental cutters have been run at the S.A.F. at 6,000 s.f.p.m. and 4 ft. per minute feed on a steel block. Our experience, however, has been that such high speeds are not economical.

Feeds

A minimum feed of 0.005″ per tooth is generally recommended for carbide milling. Frequently much greater feeds are used, but available H.P. and chip disposal are often limiting factors. Normal feeds used at the S.A.F. range from 0.001″ to 0.010″ per tooth.

Coolants

It is well known that for carbide machining either an ample flow of coolant should be used or none at all. In most of our applications dry cutting is employed. In some cases the use of compressed air enables efficient disposal of the chips.

Surface Finish

A comparison of the finishes obtained when using high speed steel and carbide milling cutters shows that, in general, the higher speeds used with carbide cutters enable a better surface finish to be obtained.

Modes of Wear or Failure

Common examples of the wear or failure of carbide tipped milling cutters include :

(1) Cracking of the tip due to careless brazing or grinding.
(2) Failure of the brazing medium.
(3) Fracture of the tip due to careless handling in transport from the cutter grinding section to the production shop. All cutters should be amply protected and preferably transported in lined boxes.
(4) Fracture of the tip due to careless handling by the machine operator. In this connection it is important to note that operators should be carefully educated in the use and care of carbide cutters.
(5) Failure of the tip due to choice of an incorrect grade for the particular application.
(6) Wear during normal cutting. Reconditioning of a worn cutter at the right time is a simple matter and requires merely a few minutes' work. A tool driven beyond its economic life between sharpens requires much more time to recondition it and results in considerable wastage of carbide.

Removal of the tool from the work at the right time will mean more regrinds per tool.

Cutter Sharpening

Our experience is that cutter sharpening is an extremely important factor in the success of carbide milling. Modern precision cutter grinders, with the necessary fixtures and the use of the proper techniques will ensure properly ground surfaces. Experienced and adaptable cutter grinder operators always do this work at the S.A.F., where a special section has been set up. Nevertheless, such operators have required special training to adapt themselves to the new techniques that are required for sharpening carbide cutters.

The finish of the tool and particularly the finish of the cutting edge has a marked influence on tool performance. Machines such as Cincinnati tool and cutter grinders are used. The shank and tip are rough ground with silicon carbide wheels and the tip is finished with diamond impregnated wheels. To impart smooth cutting edges to the tips they are finished with a diamond lap.

Power

Where a particular machining operation is converted from a high speed cutter to a carbide cutter increased power input is generally required, due to the increased speeds and feeds employed. Mention has already been made of the fact that in many cases the number of teeth in the cutter are limited by the available power of the machine.

Plant

With regard to plant it is thus often found that many older machines do not have the necessary power or a sufficient range of speeds and feeds for carbide milling. In general, best results are obtained with carbide cutters by using modern heavy duty equipment.

Another point that may be mentioned in connection with plant is the effect of greater productive machine capacity on floor space requirements. For instance, in a new section fewer milling machines may be required for a given volume of production, thus reducing total floor space requirements. In a section already established, fewer machines may be necessary to obtain the normal volume of production, or a larger total volume of production may be obtained from the present number of machines.

Economics of Tungsten Carbide Milling Cutters

Owing to their high initial cost, tungsten carbide milling cutters must give a greatly improved performance in comparison with other milling cutters if they are to prove economical in practice.

Tungsten carbide milling cutters have been used at this factory for several years and, over this period, the relative economy of the tungsten carbide bit has been amply demonstrated on production runs. It must be emphasised that every carbide milling problem must be considered individually and the merits of steel and tungsten carbide should be fully investigated before a final decision is made. It is a general rule, though there are exceptions, that on long production runs the higher initial cost of carbide tooling pays dividends, while on short production runs it may not be justified. Cost relationship is very important in considering the use of carbide cutters and for this reason a cost analysis has been set out in this lecture.

Any investigation into the economics of carbide milling must include all the factors which together

COMPONENT No. XYZ.

Sharpen cutter after 100 components
Production Rate=10 per hour

	£	s.	d.
Initial cutter cost	10	0	0
Set up in machine		10	0
Machine 100 components	5	0	0
TOTAL	£15	10	0

Cost per component=37.2d.

	£	s.	d.
Sharpen cutter	1	0	0
Set up in machine		5	0
Machine 100 components	5	0	0
TOTAL	£21	15	0

Cost per component=26.1d.

Power consumption costs have been neglected.

Fig. 2

make up the total cost, but it will be apparent that there are three items which affect the result to a great degree. The first of these is the hourly output which is closely linked to the feed, the second is the initial cost of the cutter and the third is the life of the cutter.

The remainder of this Lecture will consist of eleven typical carbide milling jobs at present in operation. In each case, the cost of production has been compared with the cost of production with high speed cutters which were used before tungsten carbide was applied to the job.

Fig. 2 shows how the cost analysis has been made. Power consumption costs have not been directly included but are contained in the overheads which comprise part of the labour costs. Such an analysis has been made for both high speed steel and tungsten carbide cutters on each job and after computing the cost at a number of production outputs, the values have been plotted in the form of graphs such as Fig. 4.

It is thus possible to ascertain the relative merits of tungsten carbide and high speed cutters at any production level. The ultimate saving brought about by the use of the tungsten carbide cutter expressed as a percentage of the cost at any particular level when using a high speed steel cutter is set out at the top of the graph. This is seen to approach a constant value.

The remainder of the lecture will comprise a presentation of the relative merits of tungsten carbide and high speed cutters on eleven typical milling jobs, each of which has been performed by both methods.

Job No. 1

General Description

This is a straddle milling operation using two side and face cutters. The machine is a rigid bed type milling machine and the spindle is well braced. A 2-station set-up is employed, each fixture consisting

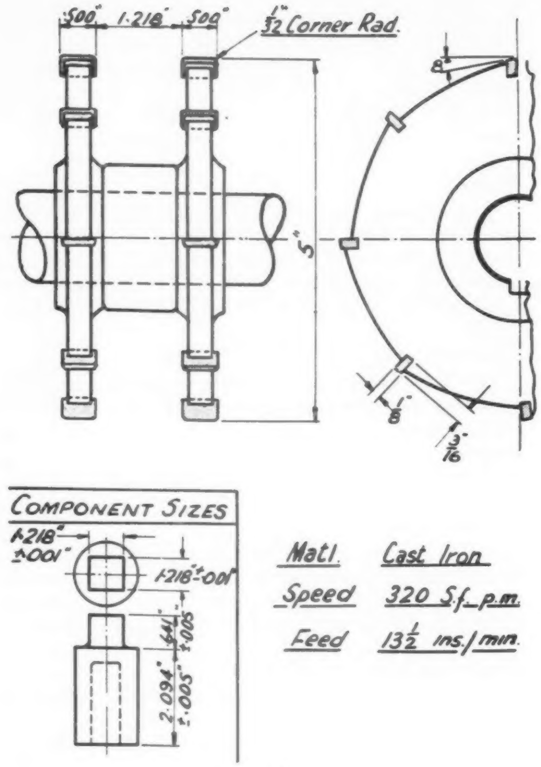


Fig. 3.

of a 3-jaw chuck set vertically and attached to a dividing head which enables two cuts (at 90°) to be taken on each component. (Climb milling at one end of the table and orthodox milling at the other.) The component material is cast iron.

With tungsten carbide cutters the speeds and feed are as follows:

Speed: 320 s.f.p.m. (100 s.f.p.m. HSS).
Feed: 0.007" per tooth (0.002" HSS).

The floor to floor time has dropped from about 1 minute using HSS to 30 seconds using carbide.

Cutters

The HSS cutter previously employed was a standard 5"×½"×1¼" side and face cutter. The carbide cutter is shown in Fig. 3. The axial and radial rakes are both zero. The corners are strengthened by use of a 1/32" radius. Once the cutters are worn on one side they may be interchanged. The component is sketched at the bottom of Fig. 3.

Costs

The initial cost of the carbide cutters was approximately twice that of the HSS cutters, but the production rate was considerably increased and the life between sharpens increased from 1,000 to 5,000. A cost analysis was performed as explained previously and the result is shown in Fig. 4. The carbide cutter does not prove economical until 4,000 components

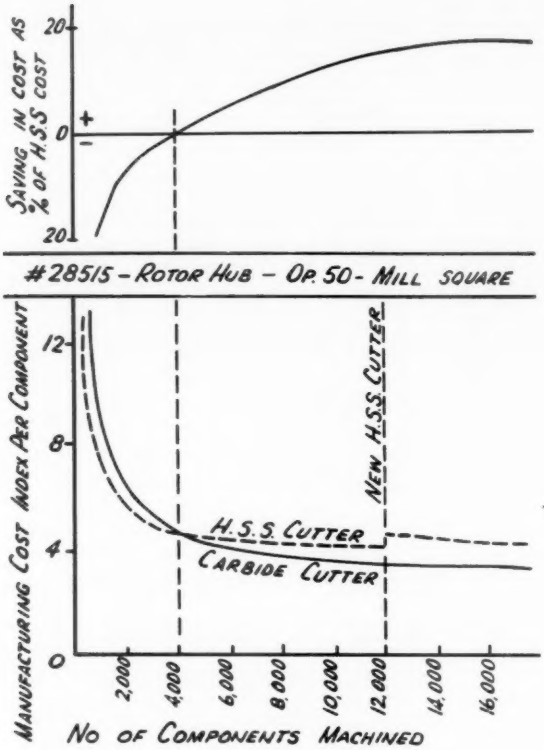


Fig. 4.

have been machined, after which a 20% saving eventually becomes obvious. Thus at our production rate on this component the carbide cutter proves the more economical after a few weeks' production.

Job No. 2

General Description

Fig. 5 shows the second job which is another straddle milling operation on cast iron using a gang of four side and face cutters. The cutters are amply bossed and well supported. The single station fixture works with a simple toggle action. Climb milling is employed thus forcing the thrust down on to the base of the machine and away from the clamp handle. The speed is 230 s.f.p.m. (80 s.f.p.m. HSS), and the feed is 0.008" per tooth (0.002" per tooth, HSS). Again the floor to floor time has dropped from 1 minute to about 30 seconds. Up to the present 6,000 components have been machined without resharpening of the carbide cutters, compared with an average life of 1,000 between sharpens with HSS cutters.

Cutters

With HSS, standard side and face cutters may be used. The carbide cutter is shown in Fig. 6, and in this case the axial and radial rakes are both +10°. The corners of the teeth are strengthened by use of a 1/32" chamfer. The nature of the cut is shown at the bottom of Fig. 6.

Costs

High speed and carbide cutter costs were compared and the result is shown in Fig. 7. Since the carbide cutters enable a production rate nearly double that with HSS cutters, they soon overcome the disadvantage of their increased first cost and tend towards an ultimate saving of about 50%.

Job No. 3

General Description

The third job is a straddle milling operation on a nickel-chrome-molybdenum steel component, which is held in a cam-operated vice on a well braced bed

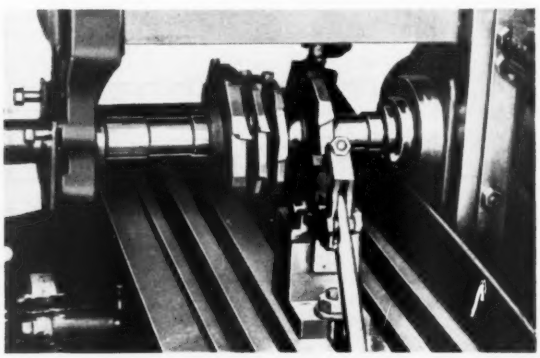


Fig. 5.

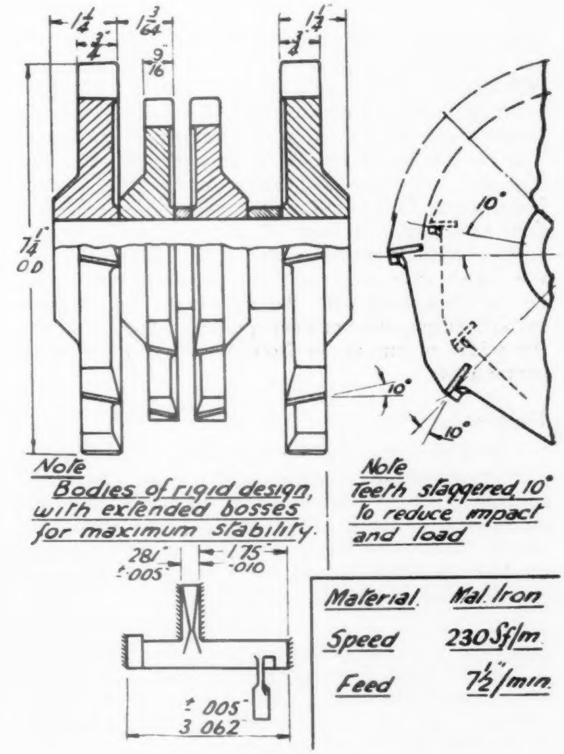


Fig. 6.

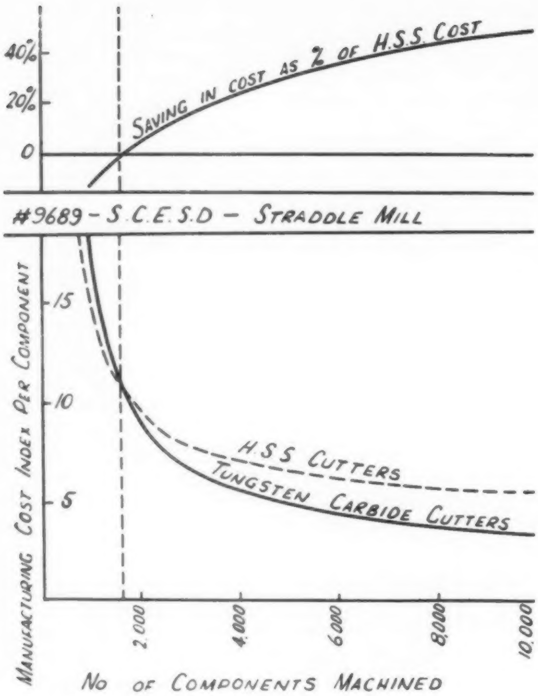


Fig. 7.

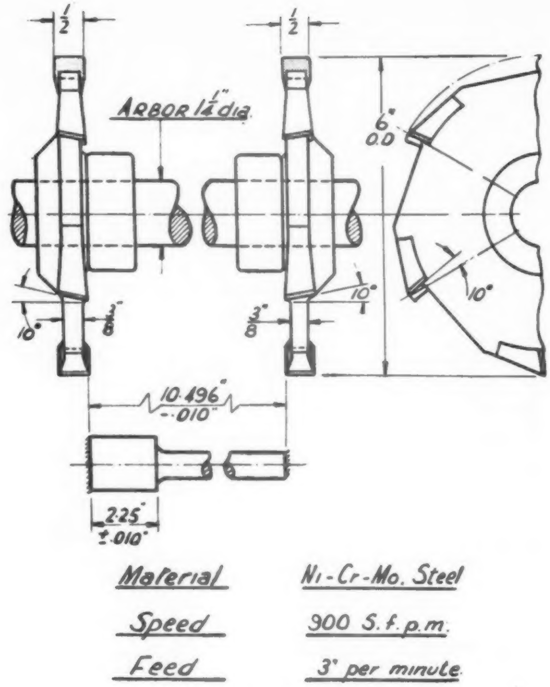


Fig. 8.

type machine. For experimental purposes the speed at which this carbide cutter was operated was 900 s.f.p.m., with a feed of only 0.001″ per tooth. With HSS a speed greater than 40 s.f.p.m. could not be employed because of the roughness of the forgings. The carbide speed of 900 s.f.p.m. appears to be too high for economical life and a lower speed is now being tried. Climb milling is employed. The floor to floor time dropped from $3\frac{3}{4}$ minutes to $1\frac{3}{4}$ minutes when a carbide cutter replaced the HSS cutter but the latter gave a greater life between resharpens, i.e. 400 compared with 200 for carbide because this carbide cutter has not been properly developed and the width of cut varies from 1/16″ to $\frac{3}{4}$″ between components.

Cutters

The HSS cutter is a standard side and face cutter. The experimental carbide cutter which is to be modified in the future is shown in Fig. 8 with the component below it. The ample bosses should be noted. At present the possibility of using fly cutters on this operation is also being investigated and a superior performance is anticipated.

Costs

Fig. 9 shows the cost relationship. The initial costs of the HSS and carbide cutters are practically identical and since the latter enables a doubling of the production rate, it proves more economical from the start, giving an ultimate saving of 40%.

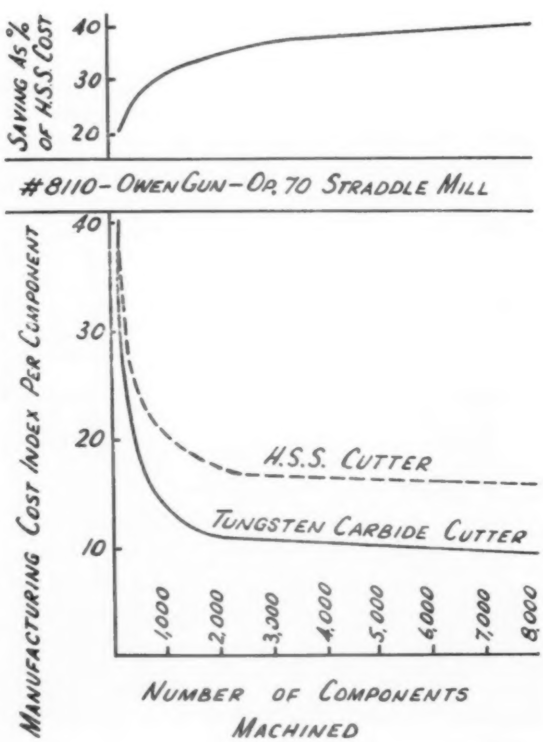


Fig. 9.

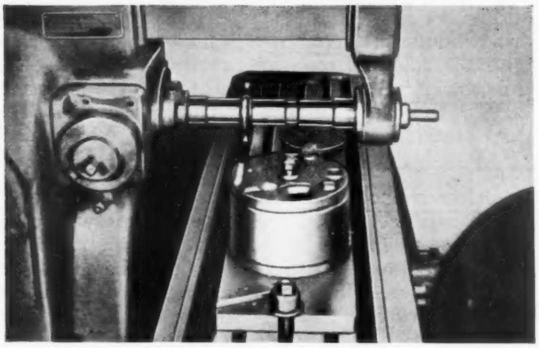


Fig. 10.

Job No. 4

General Description

Fig. 10 shows the fourth job, a cast iron component being slotted by a single cutter. A single station fixture consisting of a spigot on which the work is located and a simple spanner type split washer clamp are employed. This is a further example of climb milling.

With carbide the speed has been increased to 475 s.f.p.m. from 110 s.f.p.m. for HSS and the feed to 0.004″ per tooth from 0.003″ per tooth.

The reduction in floor to floor time is not great, i.e. from 75 seconds to 60 seconds.

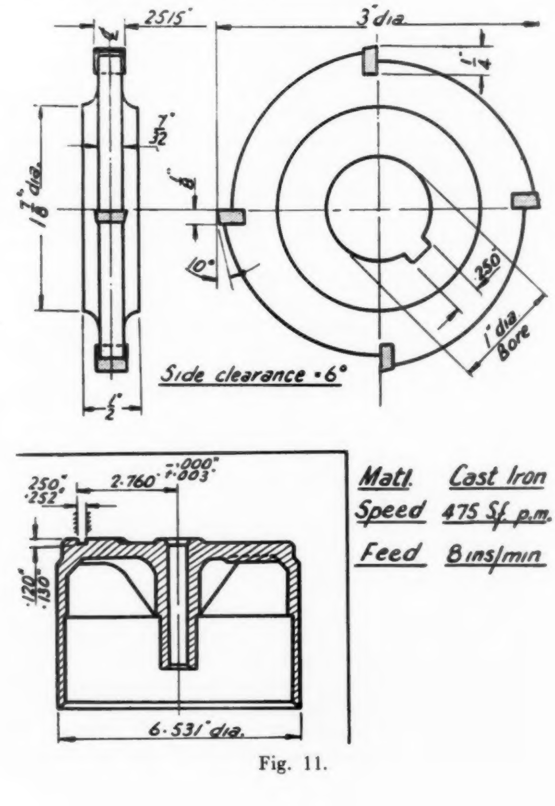


Fig. 11.

Cutters

The HSS cutter was a standard 3″×¼″×1″ side and face cutter. The carbide cutter is shown in Fig. 11, and the job is illustrated below it. The carbide cutter is well bossed. It is to be noted that the slot width must be maintained within 0.002″. The radial and axial rake angles are both 0°. When the carbide cutter tips are worn they may be taken out and rebrazed in staggered fashion and put back on the job, whereas HSS cutters would have to be scrapped.

Costs

The cost analysis is graphed in Fig. 12. It has already been mentioned that the carbide cutter does not enable a greatly increased production rate (25%), but the life between sharpens is about 20,000 compared with 4,000 for HSS. The carbide cutter proves the more economical after machining 2,000 components and enables an ultimate saving of 20%.

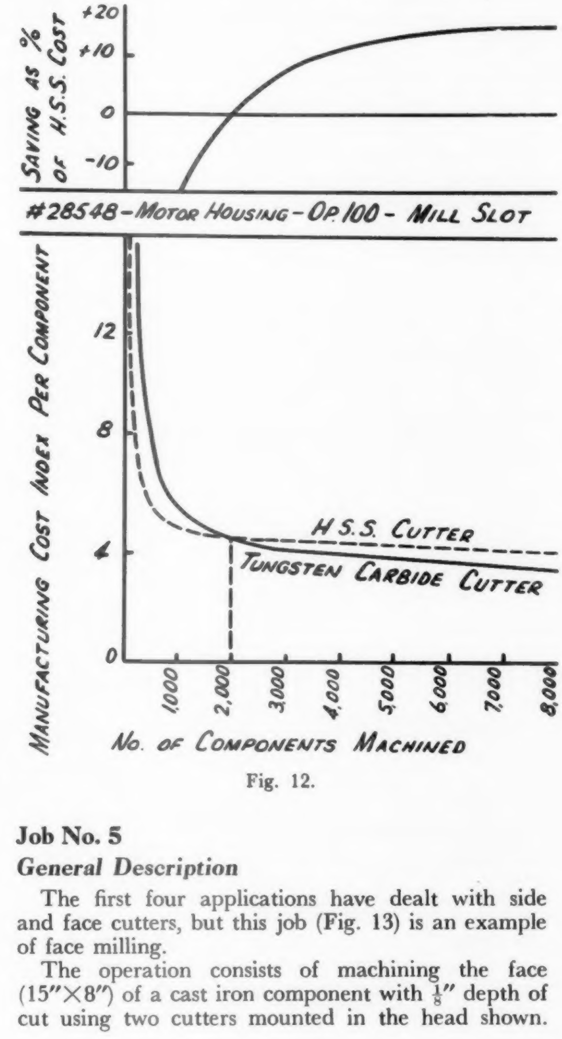


Fig. 12.

Job No. 5

General Description

The first four applications have dealt with side and face cutters, but this job (Fig. 13) is an example of face milling.

The operation consists of machining the face (15″×8″) of a cast iron component with ⅛″ depth of cut using two cutters mounted in the head shown.

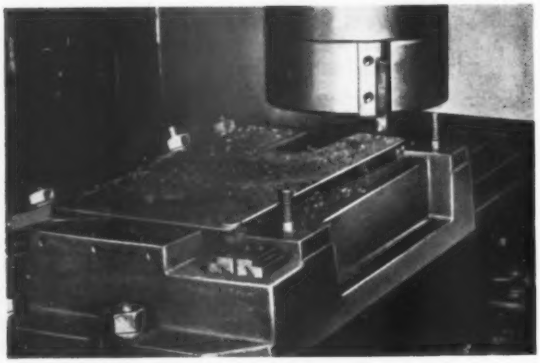
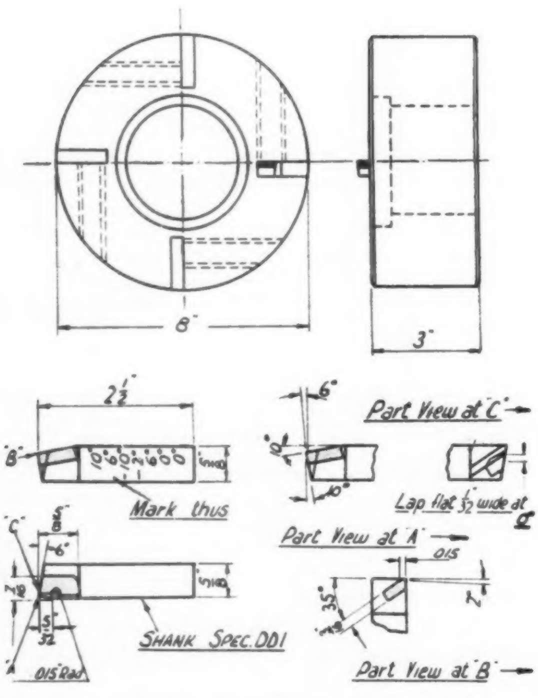


Fig. 13.

The head is 8" diameter×3" deep and above it is mounted a flywheel of the same dimensions so that the two provide ample momentum to resist speed fluctuations.

Speeds: Carbide = 700 s.f.p.m.
HSS = 90 s.f.p.m.
Feeds: Carbide = 0.007" per tooth;
HSS = 0.002" per tooth.

The carbide floor to floor time was four minutes, compared with 14 minutes with HSS cutters. With HSS cutters there was a great deal of distortion of the work due to heating, but this does not occur with carbide cutters.



FLY CUTTER HEAD & TOOL

Fig. 14.

Cutters

Fig. 14 shows the general details of a fly cutter head and tool. Different sizes of these heads are stocked and also standard tools for cast iron and steel. The tool shown is actually for steel, having a 10° negative axial rake and 2° negative primary radial rake. The tool marking system shown simplifies resharpening.

Costs

Before the carbide cutter was put on the job a cutter with 14 high speed steel inserts was used. Assuming that the heads used in both cases are standard equipment, it was found that the cost of the high speed steel inserts was much greater than that of the two carbide teeth and the life between sharpens of the 14 HSS teeth was only two components compared with 20 for carbide. Sand inclusions in this component have been very severe on the tools.

Introduction of carbide on this job enabled the production time to be greatly increased. Consideration of all these factors showed that the carbide cutters proved best from the start and gave an ultimate saving of 60% as shown in Fig. 15.

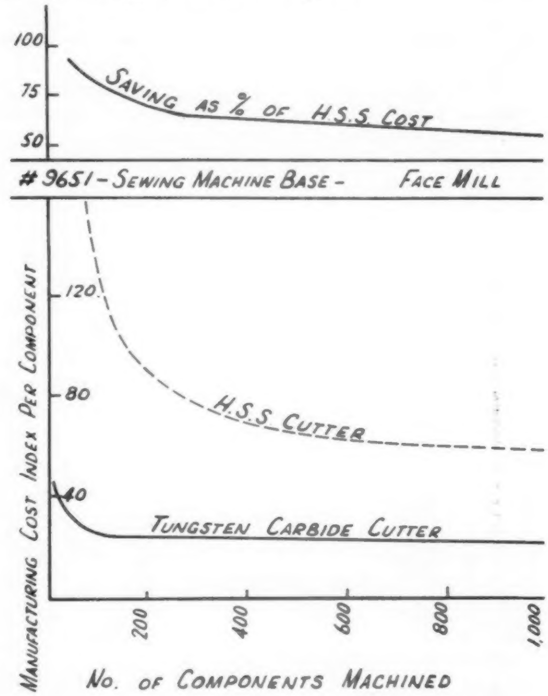


Fig. 15.

Job No. 6

General Description

In this job, a fly milling cutter is used to clean up the central portion of a channel shaped steel component which is about $13\frac{1}{2}$" long by 5" wide with $\frac{1}{8}$" depth of cut. The surface finish produced on this job is quite good being about 40 micro-inches. There is no flywheel but the cutter head is $5\frac{1}{2}$" diameter by 4" deep. On this job compressed air is used to remove

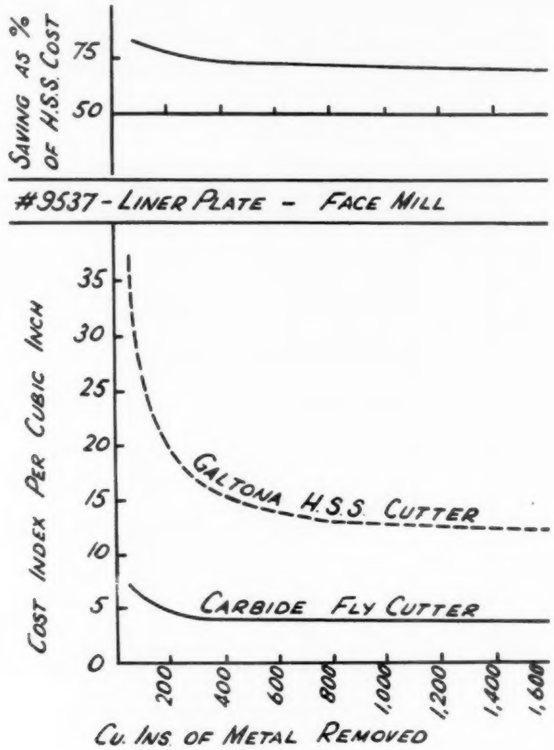


Fig. 16.

the chips. This particular operation had not previously been performed with a HSS cutter, but figures for a similar facing operation with only 0.030″ depth of cut on the same component with a Galtona type cutter, shown in Fig. 16, having 10 HSS teeth have been compared with that for the carbide cutter in terms of volume of metal removed.

Speeds: Carbide=600 s.f.p.m.;
HSS=80 s.f.p.m.

Feeds: Carbide=0.009″ per tooth;
HSS=0.006″ per tooth.

Cutters

The carbide tool is of the fly cutter type shown previously.

Costs

The rapid production rate made possible by use of a carbide cutter enables it to exceed the performance of the HSS cutter from the start and so the graph of Fig 16 shows an ultimate saving of about 70%.

Job No. 7

General Description

This is the third and final face milling operation to be considered. In this case a comparison has been made of the machining of a face of a rough steel forging 7 feet long by 8 inches wide with an average depth of cut of $\frac{3}{8}$″. This depth varies greatly due to the roughness of the forgings.

At present the cutter head is 7″ diameter by 4″ deep, and above it is mounted a flywheel 8″ diameter by 4″ deep.

The HSS cutter employed on milling another face of the same component is a helical slab mill with twelve inserted teeth.

Speeds: Carbide=400 s.f.p.m.;
HSS = 20 s.f.p.m.

These are restricted due to the roughness of the forgings.

Feeds: Carbide=0.003″ per tooth;
HSS =0.004″ per tooth.

Reduction of the floor to floor time by using carbide enables a doubling of the production rate. The single carbide cutter tooth has a life of one component between resharpens compared with six components for the HSS cutter.

Cutters

The carbide fly cutter was a standard type.

Costs

Again Fig. 17 shows that the carbide cutter is best from the start and enables an ultimate saving of 40%.

On the three face milling jobs shown it may be seen that the carbide proves definitely superior to HSS at any production level. If standard heads, flywheels and standard tools are stocked, even short

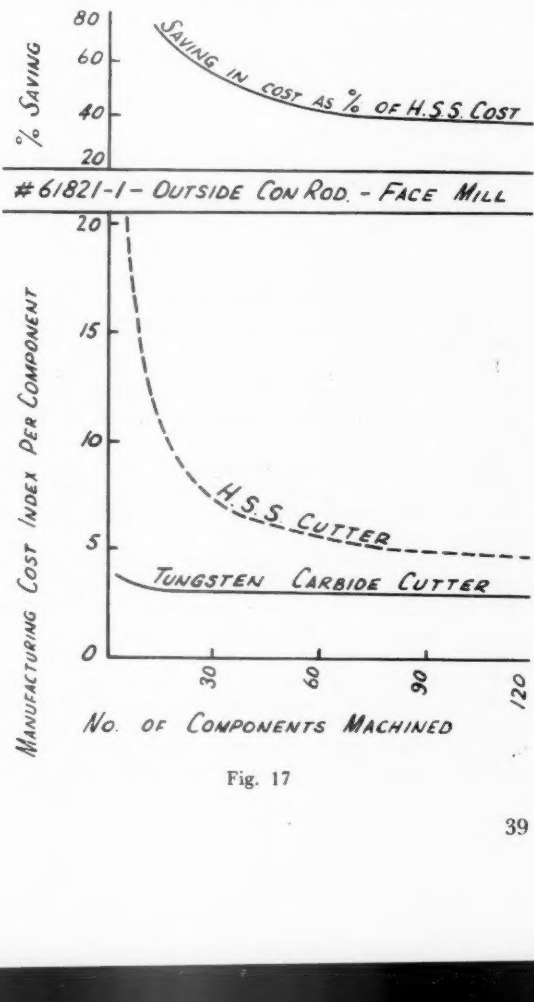


Fig. 17

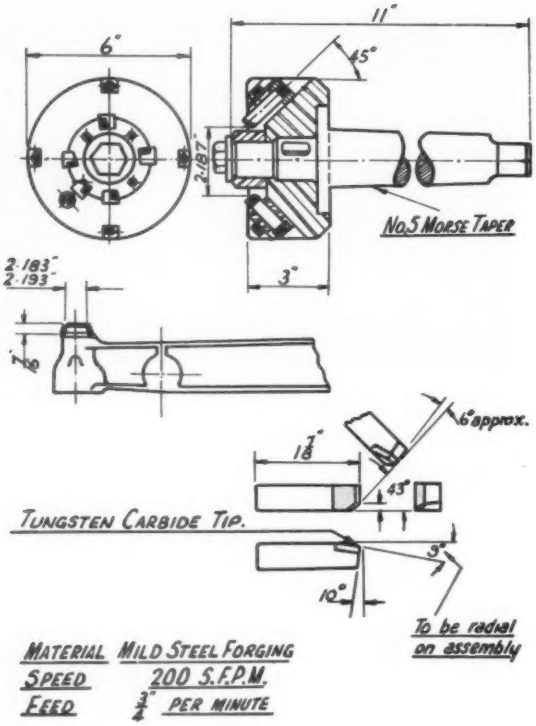


Fig. 18

production runs may be economically completed with this type of carbide cutter.

Job No. 8

General Description

The eighth job introduces the transition from the three face milling jobs previously considered to end milling applications of tungsten carbide.

The operation is performed on vertical drilling machines. Bosses on both ends of a forged steel tractor axle are hollow milled. With carbide, a speed of 200 s.f.p.m. and feed of 0.002″ per tooth are used, compared with 90 s.f.p.m. and 0.001″ per tooth using HSS cutters.

Floor to floor time has been reduced from $3\frac{1}{2}$ minutes to $1\frac{1}{2}$ minutes. Tungsten carbide has a life of 200 between sharpens compared with 60 for HSS.

Cutters

Fig. 18 illustrates the arrangement of the carbide cutters. The four equally spaced teeth take the main cut, the fifth tooth being used only to provide a chamfer.

The form of carbide insert is illustrated at the bottom of Fig. 18. It has a 9° negative axial rake and zero radial rake. The tools are set against a ring which is slipped over the pilot on the cutter.

Costs

The carbide inserts are very cheap and when HSS is used a similar head must be made up so that the initial cost of the carbide cutter compares very favourably with that of the HSS cutter. In addition, carbide enables the production rate to be more than

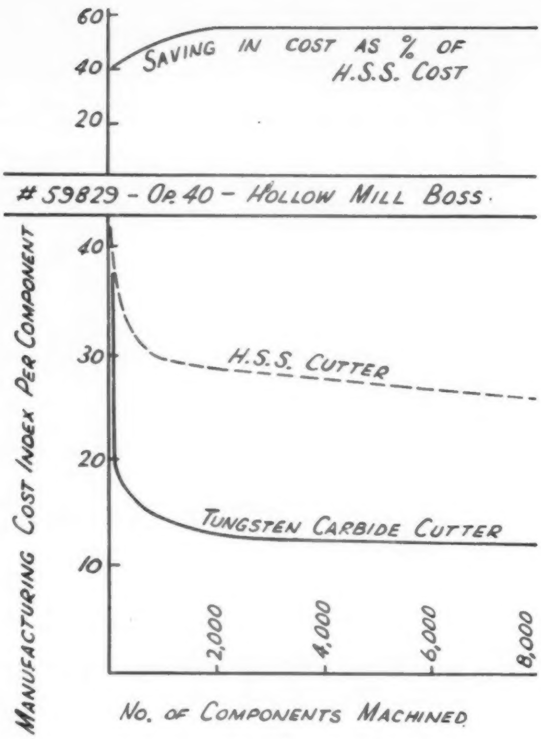


Fig. 19

doubled, so that it proves more economical from the outset and gives an ultimate saving of about 60% (Fig. 19).

Job No. 9

General Description

Job 9 consists of a very light (0.030″) end mill cut on a small hand milling machine. The material is cast iron and the speed was 80 s.f.p.m. for HSS and is now 180 s.f.p.m. for TC (this being the maximum for the machine). The hand feed was the same for both the carbide and HSS cutters.

The main advantage to be gained from the carbide is therefore the increased life between sharpens, which is 8,000 compared with 2,000 for HSS. The component is located by three small spigots and held by a simple clamp.

Cutters

A standard HSS cutter was previously employed and was replaced by the carbide cutter shown in Fig. 20. The axial rake is +6° and the radial rake is zero.

The component is shown in the bottom portion of Fig. 20.

Costs

The carbide cutter gives a slightly greater production rate and a much greater life between sharpens than the HSS cutter, although its initial cost is much greater. Nevertheless Fig. 21 shows that it proved superior, although the ultimate saving was not very great.

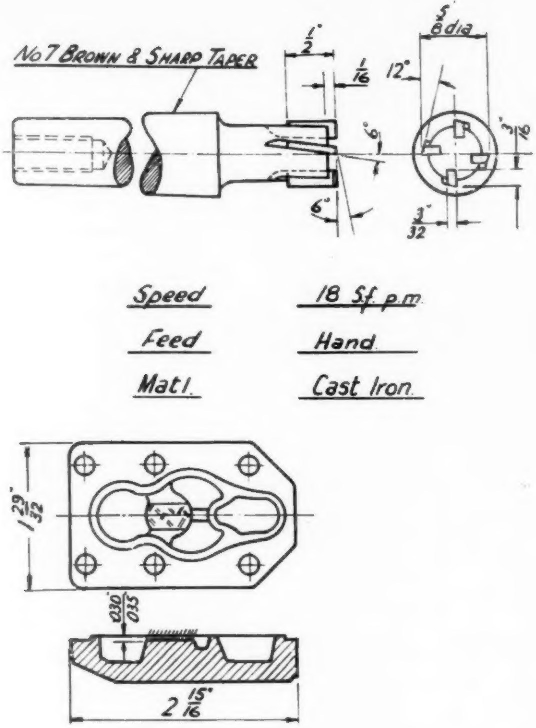


Fig. 20.

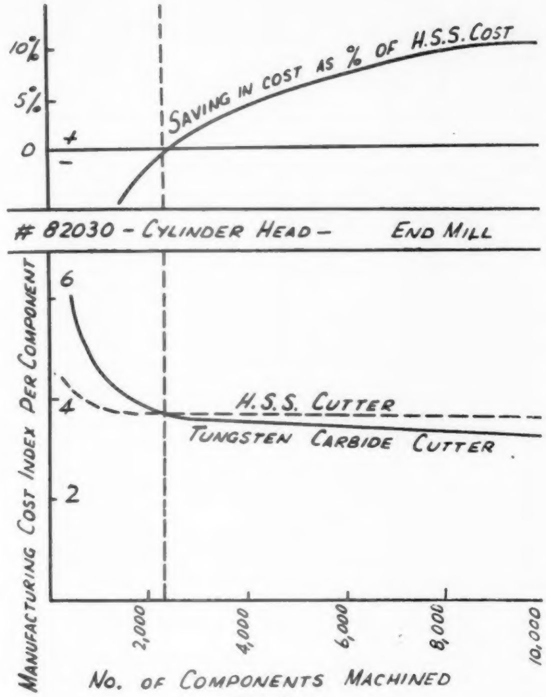


Fig. 21.

Job No. 10
General Description

This consists of profiling a cam form on a previously turned cast iron cylinder. The cutter is a simple form cutter. The component is located on the centre spigot and the table to which this is attached revolves with an eccentric motion while the cutter rotates. The carbide cutter machines at a speed of 420 s.f.p.m. and feed of 0.002" per tooth and the HSS cutter at 90 s.f.p.m.

Floor to floor time was reduced from 4.3 minutes to 2.3 minutes.

Cutters

The HSS and carbide cutters are similar, the latter being shown in Fig. 22. The axial and radial angles are both zero. The formed portion of the teeth consists of a $3\frac{1}{16}$" radius as shown. The component is illustrated at the bottom of Fig. 22. All dimensions must be maintained to within 0.0001" and the form must be symmetrical to within 0.0003".

Costs

The cost of the carbide cutter was initially eight times that of the HSS cutter, but it enabled a doubling of the production rate and the life between sharpens was increased from 200 to 1,000. It soon proved the more economical, (Fig. 23), and gave an ultimate saving of 40%.

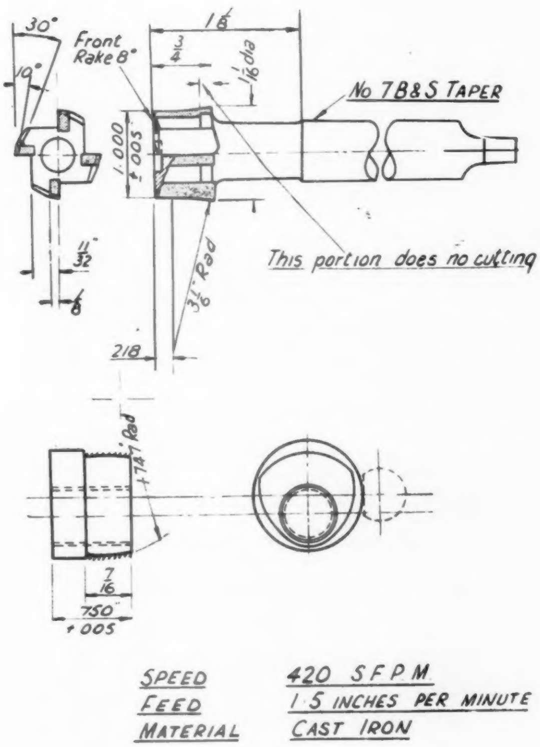


Fig. 22.

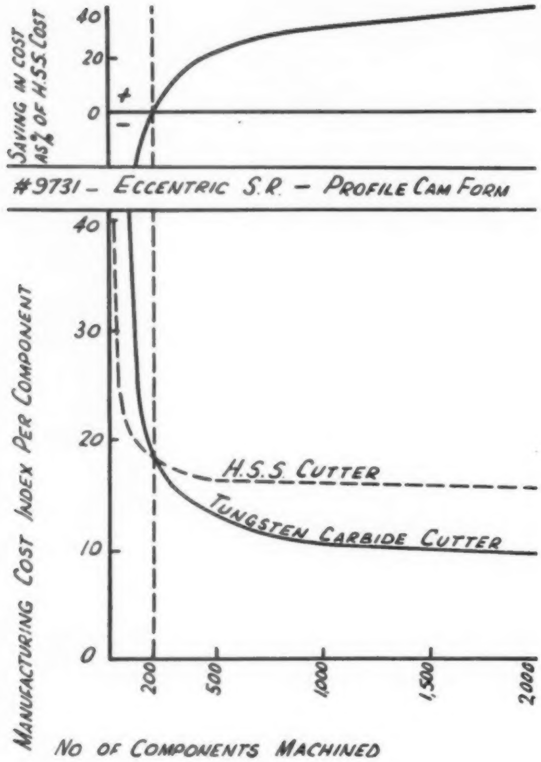


Fig. 23.

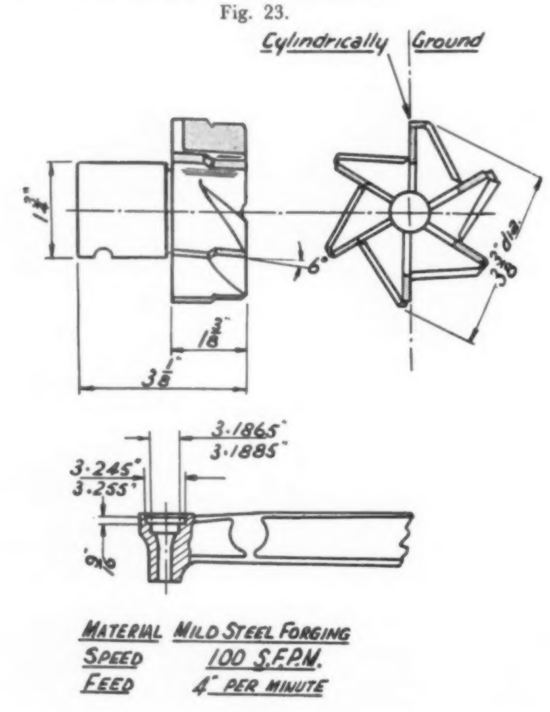


Fig. 24.

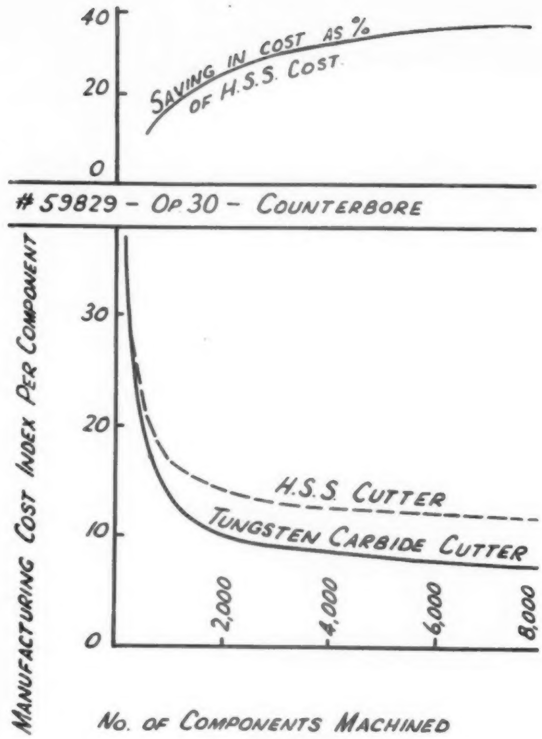


Fig. 25.

Job No. 11
General Description

The last job to be considered is essentially a counterboring operation performed on a vertical spindle drilling machine. The component is of forged steel. The carbide cutter operates at 100 s.f.p.m. and 0.006″ per tooth, compared with 70 s.f.p.m. and 0.002″ per tooth for steel.

Floor to floor time dropped from 1.8 minutes to 1.3 minutes, while the life between sharpens was increased from 80 to 200 holes.

Cutters

Fig. 24, shows that this is another simple form cutter. Actually the teeth are stepped to make the cut illustrated on the small scale component drawing. The cutter has six teeth with zero radial rake and 6° axial rake.

Costs

Fig. 25 shows the cost comparison. Carbide proves more economical from the outset since it gives an increased production rate and the initial cost is almost the same as for a HSS cutter.

Conclusion

These eleven examples have illustrated the superiority of tungsten carbide tipped milling cutters over conventional high speed cutters on straddle

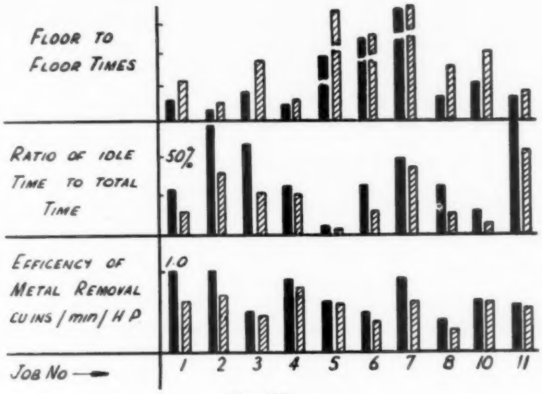


Fig. 26.

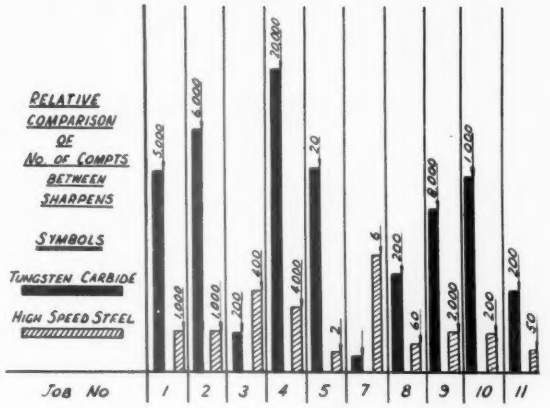


Fig. 26(a).

milling, slotting, face milling, and end milling on both light and heavy cuts on climb and orthodox milling and under a variety of conditions. The problem of form milling has not really been tackled, as the last two jobs discussed do not furnish good examples of this. As yet we have not applied carbide to this type of work because of the problems involved.

In all cases the advantages on production runs have been made obvious. To sum up, Fig. 26(a), shows how increased life between sharpens has been obtained in almost every case by the use of tungsten carbide. The top graph of Fig. 26, shows how in all cases floor to floor times have been reduced and in many cases the production rate has doubled, but it is felt that full advantage is not being taken of the capabilities of tungsten carbide. This is illustrated by the middle chart. When carbide cutters are introduced on any particular job, the actual cutting time is greatly reduced but the idle time (that is, the time to load and unload the job in the machine) does not change. Hence, the idle time forms a greater percentage of the total time than it does with high speed steel cutters. The only way to overcome this is to use multi-station fixtures. If this were done the gains would far exceed the outlay involved in making a second fixture.

Finally, for those who are interested in the machinability field the bottom graph has been included. It shows a comparison of the efficiency of metal removal of tungsten carbide and high speed steel cutters on the jobs previously considered. This efficiency, which is essentially the rate of metal removal per unit power consumption, is expressed in the universally accepted unit of cu. ins./per minute per H.P. In every case the carbide cutter is seen to be more efficient than the high speed cutter.

Acknowledgments

The Author wishes to record his appreciation of the generosity of Mr. Abbott, Manager, S.A.F., for allowing this lecture to be compiled and presented.

Very little of the information could have been presented without the enthusiasm and guidance of Mr. L. Allan, Production Engineer in charge of the Bren Gun Department, in whose section most of the pioneer work on tungsten carbide milling at this factory has been performed.

The author also wishes to acknowledge his indebtedness to Mr. J. G. Solomon and the staff of the Metallurgical Laboratory for taking the photographs and preparing the slides; to Mr. R. Nicholls, Mr. W. Boehme and Miss Rowntree of the Drawing Office for preparation of the drawings; to Mr. L. Wray, Library, for assistance in obtaining information and typing; and to Mr. J. Morris, Blueprint Room, for preparing copies at short notice.

Corrigendum

Attention is drawn to an error in the Paper, "Manufacturing Methods of Fractional H.P. Electric Motors, as seen in Switzerland", published in the November, 1953, issue of the Journal. On page 513, right hand column, line 21 should read . . . "work value 4,600 Fr."

RESEARCH PUBLICATIONS

A number of copies of the following Research publications are still available to members, at the price stated:

Report on Surface Finish, by Dr. G. Schlesinger	15/6
Machine Tool Research and Development	10/6
Practical Drilling Tests	21/-

These publications may be obtained from the Production Engineering Research Association, "Staveley Lodge," Melton Mowbray, Leics.

JOURNAL BINDERS

Members are advised that binding cases for the new size Journal are now available, and may be ordered from Head Office. The cases, which are strongly made and covered in dark red leather cloth, with "The Institution of Production Engineers Journal" in gilt on the spine, will each hold 12 copies of the Journal. The price per case is 10/-, post free.

THE ETHICS OF PRODUCTION

by R. W. MANN, M.I.E.E., M.I.Prod.E., M.I.Min.E.

Presented to the Birmingham Section of the Institution, 16th September, 1953.

Mr. R. W. Mann

Mr. Mann, who is a Past President of the North-Eastern Section of the Institution, is Managing Director of Victor Products (Wallsend) Ltd., manufacturers of mining, drilling and lighting equipment.

He is Chairman of the British Productivity Council Tyneside Committee, Chairman of the North-East Engineering Bureau, and a Member of the Council of the Northern Industrial Group.

"CARRYING coals to Newcastle" has become a world-wide expression of what was once thought to be an absurdity. I am not sure that bringing Production to Birmingham is not on similar lines!

I have two excuses to offer you in case you should consider it an offence that I am here—firstly, that I served my apprenticeship in Birmingham and much that I know of basic engineering I learned here, and secondly, that I am not intending to talk on the mechanics of production, but rather the art of persuading other people to produce.

Seeing that it is my intention to talk of certain ethical aspects of human nature, it is essential that you should know just a little of the information I took from Birmingham 35 years ago, and which has largely formed the basis on which I attempt to handle people today.

Three fundamentals have stayed with me. When I first signed my indentures, no one in my family had any connection with the engineering industry, which in those days was considered, particularly here in Birmingham, to comprise a pretty tough lot.

Much to my surprise, I found there was no fundamental difference between the man on the shop floor and myself. Apart from some small difference of education, we had almost everything else in common, and lesson number one was that I learned to like people of different kinds.

I have since learned that the habit of "liking" people is a "must", if you wish to build a team.

I never accept an apprentice who does not appear to have this ability, and I never employ a man for executive work if he expresses any opinion of looking down upon his subordinates.

My second fundamental came as an apprentice, when first introduced to piecework. At the time, I remember I was turning control cams on a completely non-automatic centre lathe. My basic rate was 5/- a week. The Company had an apprentice piecework rate of ½d. per cam, which with a steady lack of endeavour could be made to earn 6/- per week or thereabouts.

The second week I really learned to use two hands at the same time. That week I earned 15/-. Was I sent for by the foreman and congratulated? Not likely—my rate was cut to ¼d. each.

I was quick to learn during the next six months, and with the help of my workmates I became a specialist in the art of producing to suit piecework prices. No rate-fixer then or since has ever succeeded in "time and motion studying" me.

My third fundamental came during my apprenticeship. I was there doing contacts on a multi-spindle drill. There was a wide variety of small numbers "off", all of which the operator marked out for himself on a marking-off table. Any apprentice could stay overtime and make his own personal tools, i.e., calipers, scrapers, chasing tools, etc. I used my own time to devise a dividing jig which enabled me to drill the complete range of contacts without any marking-off.

This job was also piecework, but during the next week I completed a job that was supposed to last me four weeks. Did I get a bonus? Did I get an award from a Suggestions Scheme? On the following morning a deputation, consisting of the shop superintendent and the foreman of the toolroom, with suitable honours smashed my jig with a hammer,

and it was suitably explained to me that brains were the prerogative of the toolroom.

It is interesting to remember that just to convince me who was right, the toolroom never made that jig.

Finally, I took away with me a picture of the Works Progress Clerk, who was the only man who had the slightest idea of where any job was.

When asked concerning delivery, he proceeded to find that part by some form of instinct, like a well-trained terrier. Over the years I served with that Company, I saw this poor individual becoming a neurotic shadow of himself. Thus the need for system, system and more system, was ingrained.

As " clothes makyth the man " so experience makes the production engineer, and over the last 35 years I have learned that the maximum production from any kind of factory is easy, once it is based upon a number of fundamental requirements.

Let me make clear what we are going to discuss. I am here not concerned with production in the sense that it is the continued working of a known set of processes; in other words, the job of the production engineer. What I am concerned with tonight is " Productivity ", the process of producing tomorrow the same job as today either better or quicker—an increase in production per man hour.

And here again I am not concerned with the productivity that comes from the turnover from, say, a capstan to an automatic. These are merely the mechanics of industry.

Building Up a Team

What I am concerned with is building all factory workers into a team where everyone, not only the production engineer, is concerned with output. Do what you like, try what you like—without this basic requirement, maximum production will turn sour in your mouth.

Taking first things first, I am engaged in private enterprise. Profit is my motive, and I see no need to be ashamed of it.

Why then in Heaven's name should we expect our employees to be less concerned with profit? To get a greater productivity you must have three things from your workpeople :—

(1) Willingness to do a fair day's work.

(2) Willingness to use his or her brains as well as hands in the execution of that work.

(3) To accept changes of method with correspondingly lower prices as a matter of course.

Management has two ways only available to get these requirements :—

(a) It can tie itself to the idea that if there are three men for two jobs, labour can be forced to toe the line.

I have seen two major slumps in my time, and anyone with experience on a shop floor knows that as jobs run out so do people do less work. You can hire and fire to your heart's content, and still you can make no better of it.

(b) Management can accept the fact that profit belongs to all those engaged in industry, and set out to make it worth while for labour to co-operate.

This choice may be yours yet to make—my choice has long since been made.

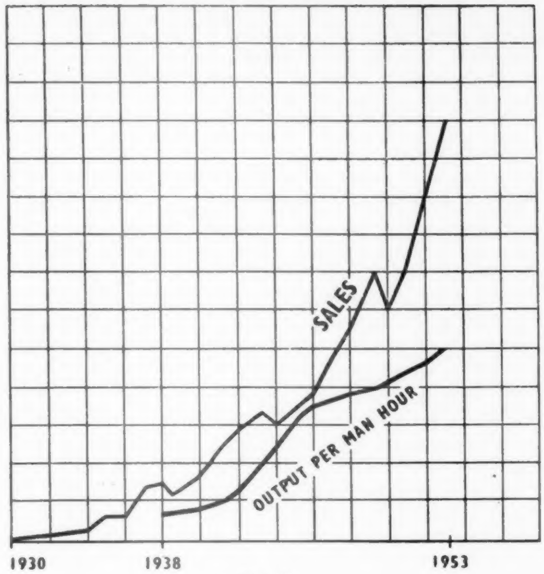


Fig. 1

Fig. 1 shows the output in sales and rate of productivity since my Company was formed.

The years 1929 to 1938 covered a period when the Company strove for its own profits only. From this date until today, the Company accepted the policy of " fair shares ".

What is " fair shares " to the working man? My experience tells me, three things, in the following order :—

1. Increased security.
2. Increased money.
3. The need to belong.

Neither the first nor the second can be provided by any Company unless more profitable ways of working are found.

Let us turn to the money issue first. I say there is not one of you in this room who does not know of at least one job on your own shop floor with a fixed price giving, say, time-and-a-half, which could not be made to earn double time. Why does not the operator do it? Largely because of lack of honesty between employer and employee.

It is not the slightest use saying you do not mind how much the man earns. It is not true. There is a price for every man and for every job, and both you and your workpeople know it. Fair price fixing is fundamental in all piecework, and until you have solved that problem there is little hope of your workpeople doing an honest day's work, or being willing to accept new methods.

If average piecework prices provide much above twice time, then the final price against the world markets will be uneconomic.

We ourselves have developed a bargain with our workpeople on these lines :—

Our Bargain

We have agreed that prices shall be fixed on a basis that for the poorest workman we are willing to employ shall provide time-and-a-half, that the expert can earn twice, and the super-expert as much as he can.

We have agreed with our workpeople that anyone incapable of making time-and-a-half under these prices shall be considered insufficiently good enough to make an adequate return on our machine costs, and can therefore be dispensed with.

We have agreed with our workpeople a method of arriving at such times not by any procedure of " time and motion study ", or rate-fixing in the usual way, but by leadership. By this I mean that any job which has to have a price fixed is actually carried out by one of the Company's senior personnel, after suitable practice to make him time-perfect. The timing of the job is carried out by an operator or a representative of the men, using a stop-watch provided by the Company.

Whatever time is achieved by the Company's expert is multiplied 2½ times for the operator. Following any change of method or for any other reason whatever, either the Company or any employee can call for a test on these lines.

This is the price for the job; under these conditions, if a man can be as expert as the Company's operator, and waste no more time than this operator, then he can earn 2½ times. In actual practice, the average bonuses for the Company work out at a shade under twice.

Under these circumstances we both accept that price for the job, " free of all bargaining ", which enables a man to accept any new methods, knowing that he cannot be the loser.

Having now agreed a fair basis for "more money ", then the workman knows as well as you that *much* more profit will be made, and he is entitled to require that some share of such extra profit shall be available, providing him with the next thing that I believe is required to produce the team.

Increased Security

My grandfather used to say that if a man wanted to retire, let him save for it. My father used to say much the same thing, but not so loudly.

During my life in the engineering industry, I have never found a time when the average working man was more than fourteen days from starvation, without a job. To talk of a working man these days saving enough on a workman's wages to retire with a reasonably decent existence is so much wishful thinking. Indeed, I will go so far as to say that there is but a fractional percentage of people in this room who can retire on their savings and keep up anything like their present standard of living.

Giving a man security out of private enterprise, instead of forcing him to expect it out of State-owned industries, can well sound the death-knell of present-day Socialism, and certainly avoids all possibility of Communism. You can give a man increased security out of profits if you want to.

Security from Pensions Schemes

Our present Pension Scheme will provide every employee at retirement with not less than half salary at time of retirement. All contributions are made by the Company.

The scheme also sets aside a certain sum of money, sufficient reasonably to secure him against want, if temporarily suspended owing to redundancy in time of bad trade.

The cost of the scheme is approximately 10 per cent. of all wages, and in the sense that it is not taxable, costs the Company less than 5 per cent., i.e. a fraction of the increased profits made by team spirit within industry.

In that the Trust Funds are invested in the Company's shares, the workpeople now own 25 per cent. of the Company, and will ultimately own one-third. Every employee is therefore a shareholder, and has achieved the third aim of " belonging ".

It is, however, not only necessary that justice should be done. It is necessary that it should be obviously done.

Here, a Works Production Committee serves the workers' idea of having a say in the running of the Company. Our own Works Production Committee consists of a freely elected member from each department in the factory, and only the Chairman is a representative of the Management. There is no question of Management losing its prerogative. Our Works Committee is treated as a department, such as the engineering department or any other, and is therefore able to make suggestions to Management which will be accepted or refused on merit alone.

With the fundamentals of a team spirit in which profit is the controlling factor for all parties, it is now necessary to provide conditions under which this position can be exploited for the good of all.

Workpeople's Suggestions

Out of my own experience, no one can convince me that the man on the job has not many opportunities of seeing a better way of doing things which is not found by systematic methods analysis. We ourselves profit by approximately 150 accepted suggestions per annum.

Rewards are nominal, and based on up to 25 per cent. of one year's saving, but a much more important reward is the publication in the Works Magazine, of photographs of winners of amounts above £5.

Methods Team

There must now be within any factory where employer/employee relations are satisfactory, a Methods Team of one or more people who are completely divorced from production and whose sole job

it is daily to investigate and introduce better methods of doing a job.

Such a team has three ways of finding work for itself :—

(1) Implementation of workpeople's suggestions.
(2) Arising out of shop floor failures.
(3) Indicated by the Costing system.

Costing

When almost everything you wish to do is hampered by non-co-operation of workpeople, a costing system is an expensive luxury. When, however, you have workpeople's co-operation, a costing system is essential.

Time does not permit me to talk at length on costs and costing; sufficient for me to express the opinion that " Standard Costing " is a " must ", reminding you that it is an impossibility without a properly operated piecework system.

Conclusion

I have not once during this evening found the need to touch upon a single engineering principle as such.

I want you to believe me that if you can provide within your own factories a set of fair circumstances where all men and women feel that they are fairly contributing to the success of the Company and fairly receiving a just share of the result, you will find automatically that the thousand difficulties of today can become nothing more than a memory.

When men work with you, instead of showing passive indifference, you will learn, as I have learned, to like people. You will have learned that a clear conscience can make the daily task a pleasure never before understood.

You will also have learned that there is profit enough for all.

I commend to your consideration those things which I have tried to explain, and I conclude with Fig. 2.

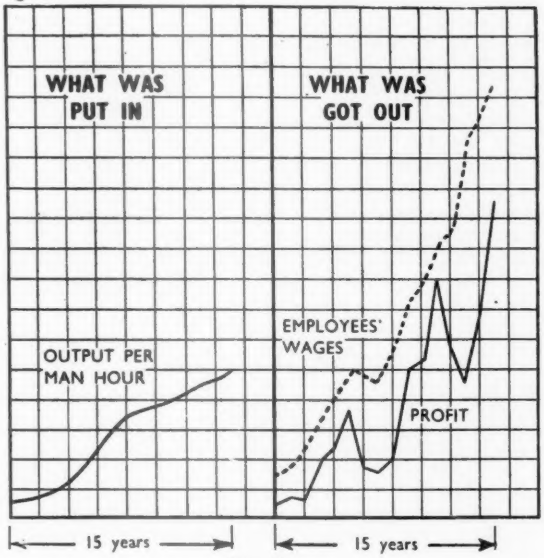


Fig. 2.

ENGINEERING PLANNING, ESTIMATING AND COSTING

The Department of Technology of the City and Guilds of London Institute has in the past offered an Examination for Mechanical Engineers' Estimates and Specifications. The Advisory Committee has recently made recommendations for the revision of the course of instruction and related examinations under the title, " Engineering Planning, Estimating and Costing ", and it is intended to provide course of training in planning and estimating, costing, works organisation, and in the presentation of information in the form of reports and letters.

The Committee has had in mind that the new examination should be suitable for those students who have already reached a standard indicated by the Institute's Final, or Full Technological Certificate in an engineering or related subject, and who wish now to study works organisation, costing and planning, with the aim of qualifying for positions of greater responsibility.

The details of the new course and of the examination, which is to be offered for the first time in 1954, are set out in a booklet published by the City and Guilds of London Institute, " 64 : Engineering Planning, Estimating and Costing ", copies of which may be obtained, price sixpence including postage, from the Department of Technology, 31, Brechin Place, South Kensington, S.W.7.

BRITISH STANDARDS

The following Standards have recently been issued and may be obtained, post free, at the prices stated from the British Standards Institution, British Standards House, 2, Park Street, London, W.1 :—

B.S. 916 : 1953	Black Bolts, Screws and Nuts, etc.	(3/-)
B.S.1262 : 1953	Tins for Paints and Varnishes and other Liquid Products of the Paint Industry.	(2/6d.)
B.S.1981 : 1953	Unified Machine Screws and Machine Screw Nuts.	(6/-)
B.S.2007 : 1953	Circular Gear Shaving Cutters : Accuracy.	(2/-)
B.S. 830 : 1953	Winchester bottles.	(2/-)
B.S.1133 Section-4 : 1953	Mechanical aids in packaging handling.	(6/-)
B.S.1157 : 1953	Tapping drill sizes	(3/6d.)
B.S.1596 : 1953	Fibreboard and composite drums.	(2/6d.)
B.S.2038 : 1953	Rolled sheet metal screw threads and associated threads in moulded plastics and diecast materials for general purposes.	(7/6d.)
B.S.2045 : 1953	Preferred numbers.	(2/6d.)

INSTITUTION NOTES

ANNUAL GENERAL MEETING

The Annual General Meeting, which is to be held on Thursday, 28th January, 1954, will now take place at 11 a.m., and not 4 p.m., as announced in the December issue of the Journal.

Formal notice of the Meeting is given on page 54.

MR. G. P. DARNLEY

Mr. G. P. Darnley, Member, who has for several years been General Manager of Bratby & Hinchliffe Limited, has now been elected to the Board of Directors and also appointed a Director of their export organisation, Messrs. Barnett, Foster & Bratby (Export) Limited.

MR. F. H. ROLT

Mr. F. H. Rolt, O.B.E., M.I.Prod.E., has retired from his appointment as Superintendent of the Metrology Division of the National Physical Laboratory, after 41 years service with the Department. Members will recall that Mr. Rolt was the author of the first Sir Alfred Herbert Paper, "The Development of Engineering Metrology", presented to the Institution in March, 1952.

Mr. Rolt intends to take up consulting work in Metrology and Standardisation and he will continue to sit on the Policy Committee of PERA.

MR. T. LORD

Mr. T. Lord, an Associate Member of the Sydney Section, arrived in this country in November and will be spending some time in the United Kingdom. Mr. Lord is Production Superintendent at Standard Telephones & Cables Pty. Ltd., Sydney.

OBITUARY

The Institution records with deep regret the death of Mr. G. W. Clarke, Member, of Standard Telephones and Cables, Limited. Starting with the Company as a tool draughtsman in 1912, Mr. Clarke occupied various positions before becoming the manufacturing engineer responsible for apparatus and equipment projects in the London (formerly European) General Manufacturing Department in London.

During the Second World War, among other activities, he made an outstanding contribution to safety in factories in connection with the operation of power presses.

Mr. Clarke will be greatly missed by his friends and colleagues in industry, many of whom have occasion to remember his kindly help and advice.

MR. F. H. PERKINS

Mr. F. H. Perkins, Member, has recently resigned his appointment as Production Manager with the North British Locomotive Company, Glasgow, and has taken up an appointment as Chief Production Engineer with Brush Electrical Engineering Company Limited, Loughborough. In addition to Mr. Perkins' duties as Production Manager with his last Company, he was also seconded by them as Production Consultant to the Indian Railway Board to develop a production engineering system at their new locomotive Company at Chittaranjan, West Bengal.

MR. E. L. TUFF

Mr. E. L. Tuff, Member, Works Manager, has been appointed a Director of The Projectile & Engineering Co. Ltd. Mr. Tuff, who has been with the Company since 1930, will continue his duties as Works Manager.

Sheffield Section Dinner

This photograph, taken at the Annual Dinner of the Sheffield Section, includes (left to right) Mr. J. H. Hartley, Section President; the Lord Mayor of Sheffield (Councillor O. S. Holmes); the Rt. Hon. Lord Sempill, A.F.C.; Mr. Walter Puckey, President of the Institution; the Master Cutler (Mr. R. L. Walsh); and Mr. G. M. Flather.

NEW APPOINTMENTS

Mr. P. A. Bouman, Associate Member, has recently taken up an appointment as Staff Member in the research in viscose silk of the Nyma, Nymegen, Holland.

Mr. L. H. Cheeseman, Member, has now been promoted to Works Manager with Addressograph-Multigraph Limited.

Mr. Peter G. Lamont, Member, has now been appointed Assistant to Motive Power Superintendent (Maintenance), British Transport Commission, British Railways (Scottish Region).

Mr. O. Hains, Associate Member, has recently been appointed Quality Control and Defect Investigation Supervisor, Trans-Canada Air Lines, Winnipeg, Canada.

Mr. J. Lamb, Associate Member, has taken up a post as Manager to The Gypsum Walling Co. Ltd.

Mr. G. Moyes, Associate Member, has taken up an appointment as Head of Mechanical Engineering, at Birkenhead Technical College.

Mr. Leonard H. Osborne, Associate Member, has now taken up a position as Second Assistant—Engineer (Mechanical), with the British Electricity Authority, Midlands Division.

Mr. M. Samuely, Associate Member, has recently been elected President of the Tubular Structures Corporation of America.

Mr. M. J. Sargeaunt, Associate Member, has been appointed Editor of *Machinery Lloyd*, London.

Professor Mansergh Shaw, Associate Member, was recently elected Dean of the Faculty of Engineering in the University of Queensland, Australia. The Faculty of Engineering in this University covers the Departments of Civil Engineering, Mechanical Engineering, Mining and Metallurgical Engineering and Electrical Engineering.

Mr. R. J. Slide, Associate Member, has recently taken up the position of Assistant Engineer with Messrs. Lankro Chemicals Limited, Manchester.

Mr. G. S. Webley, Associate Member, has taken up an appointment as Director and General Manager with Cape Engineering Company Limited, Warwick.

Mr. E. J. Bradley, Graduate, has recently taken up an appointment as Works Manager, with Welding Technical Services Limited, Birmingham.

Mr. Kevin Barry, Graduate, has now taken up a position as Senior Time Study Engineer in the Consumer Products Division of John Inglis Company, Toronto, Canada.

Mr. R. W. Dimmock, Graduate, has taken up the position of Assistant (Heavy Vehicles) to the Production Manager of Scammell Lorries Ltd., Watford.

Mr. W. H. Evans, Graduate, has taken an appointment as Designer-Draughtsman with Plowright Bros. Limited, Chesterfield.

Mr. F. L. Gillborn, Graduate, has taken up an appointment as Machine Methods Planner with Marconi's Wireless Telegraph Co. Ltd., Essex.

Mr. E. S. Nichols, Graduate, has taken up an appointment as Plant Engineer with the British Railways, Locomotive Works, Doncaster.

FUEL EFFICIENCY SERVICE

The British Productivity Council has announced the formation of a non-profit-earning Company to provide increased fuel efficiency advisory services for industry.

This Company, which will be known as The National Industrial Fuel Efficiency Service, has been formed by the Council at the invitation of the Minister of Fuel and Power, following his acceptance of the proposals of the Committee under Sir Harry Pilkington, set up by the Minister, to work out a scheme for implementing a Recommendation of the Committee on National Policy for the use of Fuel and Power Resources (the Ridley Committee).

The primary object of the Company is to provide general advice to industry and non-industrial establishments other than domestic users, and to give practical help to secure the most efficient and economical use of all forms of fuel, heat and power. By arrangement with the Ministry of Fuel and Power it will take over progressively and extend the work formerly done by the Ministry in that field.

The Company will receive no direct Government subsidy, but will be financed by contributions from the National Coal Board, the British Electricity Authority and the Gas Council, supplemented perhaps by voluntary contributions from industry and, where appropriate, by fees for its direct services.

The temporary address of the new Company will be Thames House South, 6th Floor, Millbank, London, S.W.1.

HAZLETON MEMORIAL LIBRARY

Members are asked to note that the Library will normally be open between 10 a.m. and 5.30 p.m. from Monday to Friday each week. The full facilities will not be available at the following times during the month :—

Tuesday, 12th January from 2 p.m. Thursday, 14th January from 11 a.m.
Thursday, 28th January all day.

It would be helpful if, in addition to the title, the author's name and the classification number could be quoted when borrowing books.

REVIEWS

658.54 TIME AND MOTION STUDY

" Work Measurement Manual ", by Ralph M. Barnes. 4th edition. *Dubuque, Iowa, Wm. C. Brown Co.,* 1951. 297 *pages. Illustrated. Charts.* £2. 2. 0.

Ralph M. Barnes, in the opening section of " Work Measurement Manual ", states that it is " important that time study work be carefully done by competent, well-trained people "; he emphasises that the time study engineer's work controls a considerable quantity of the company's money if the operators are on incentive, and it should, therefore, be considered seriously. He then continues: " In the past, managements have too often been negligent in administering time study work. Management has permitted the use of slipshod and careless time study practices and has failed to correct errors in time standards . . . " and have " not been aware of many ' loose ' standards until earnings have become far out of line ".

In the following sections of the book, he outlines the steps in taking a time study as a preliminary to the sections devoted to training time study engineers in rating, and training management, supervisors and operators in time study procedures. In the taking a time study section, he states: " To be of value a stop-watch study must be a study of the elements of the operation and not merely a record of the total time required per cycle to do work "; of performance rating, he stresses the need constantly to check one's accuracy: " it is not sufficient to have a hunch that you are ' about in line '; I believe that you should have data to show exactly how you stand. Top management should require this information and it would be no surprise if the union of the future demanded it ".

The Work Measurement Project then outlined requires the Barne's films and demonstration material, but the information presented could be used to very good advantage where these are not available.

Section V is devoted to statistical and graaphed methods in analysing results of work measurement studies, to see how consistent the engineer or company is with its rating. Many practical examples are given of actual training projects.

The later sections of the manual are devoted to reprints of articles and systems; included are the Learning Curve and the Time Study Training Programme at the Maytog Company; whilst considerable attention is given to the use and development of standard data.

Section VIII contains useful Industrial Engineering information obtained from surveys of American Companies, together with reprints of clauses apertaining to time study, etc., which appear in American Union contracts.

This Manual is of considerable value to both management and time study engineers. G.R.B.

669 METALS: METALLURGY

" Engineering Metals and their Alloys ", by Carl H. Samans. *New York, Macmillan,* 1952. 913 *pages. Illustrated. Diagrams.* £2. 16. 0.

This easily readable book attempts to review the whole field of modern metallurgy from the occurrence of metals to their underlying physics, from the manufacture of metals and alloys to the reasons for the use of each alloy type in engineering. It therefore describes in adequate detail the extraction of the eight engineering metals, not in the order of tonnage used, but in the order of the electro-chemical series. This logical approach has been attempted throughout the book.

Chapters I and II introduce the engineer, for whom the book is intended, to metallurgical ideas through concepts with which he is already familiar, the metallurgical reasons why safety factors are desirable, why metals differ in physical and mechanical properties. At the same time as he discusses each property, the author describes the theory and practice of " testing " that property.

Chapters III to VIII describe the modern methods, and also give an indication of the underlying chemical theory, of the extraction of the eight engineering metals. Iron, because of its pride of place from a tonnage point of view, merits two chapters to itself.

Equilibrium diagrams are given only Chapter VIII to themselves and thereafter are used solely as tools in subsequent chapters to explain heat treatment, mechanical working, etc.

Chapters X and XI describe the heat treatment of both ferrous and non-ferrous metals, dealing finally with methods of mechanical deformation. In no part of the book is any attempt made to draw artificial distinctions between alloys of iron and those of the other metals.

Chapters XI and XII deal with corrosion and protection from corrosion, this section being the most sketchy and least dealt with of any in the book.

The remaining Chapters, XIII to XX, take in turn

each engineering reason for choosing alloys, viz. ease of fabrication, resistance to corrosion, great strength bearing alloys, etc., and discusses the metallurgical reasons for choosing the particular alloys used. This approach is interesting in that it presents the relative merits of such alloys as cupro-nickels and aluminium-magnesium for use in the wrought form, but at the same time it makes it difficult, if not impossible, to trace the behaviour of a metal as greater percentages of an alloying element are added. For instance, the brasses are dealt with in *three* main sections, the equilibrium diagram, the microstructure and the heat treatment, spread over some 300 pages and mixed in with other systems. The remainder is scattered in small paragraphs throughout the whole of the last seven chapters.

The diagrams and photographs are well chosen and clearly reproduced. The practice of placing side by side a line diagram and photograph of the same plant and sometimes also a diagrammatic layout (the author calls them schematic) is to be highly commended.

All standard specifications referred to are American.

The book, blatant Americanisms apart, is well written and quite readable and does not assume background knowledge beyond a student working for the Associateship examination,* whilst at the same time, parts are also ideally suited even for Higher National candidates gaining their first insight into metallurgy.

F.B.E.

*Associate of Institute of Metals (presumably).

658 INDUSTRIAL ORGANISATION: MANAGEMENT

"**Functions of the Executive**" by Chester I. Barnard. *Cambridge, Mass., Harvard University Press. (London, Oxford University Press)*, 1947. 334 *pages*. £1. 16s.

The author has covered his subject so that the guiding principles apply to any type of organisation, i.e. business, government, education, religion, etc.

In the early chapters the theoretical considerations of any human organisation are dealt with, such as personal reactions, physical limitations, principles of co-operative action, social problems and the interdependence of all these factors on each other. This section of the book is, therefore, concerned mainly with basic and fundamental principles of human relationships and expresses the author's own philosophy on the subject.

To the reader more interested in the application of these basic factors in executive control, this phase is covered in Sections 3 and 4 where the functions of leadership, decision, incentive, responsibility, etc., are examined in a most critical manner and expressed in infinite detail.

Drawing from his vast experience, the author gives in this volume a careful analytical synthesis of the more fundamental factors that are often taken for granted when the function of the executive is normally review.

H.L.M.

ABSTRACTS

621.81 MACHINE ELEMENTS

"**Engineers' Illustrated Thesaurus,**" by Herbert Herkimer. *New York, Chemical Publishing Co.,* 1952. 572 *pages. Illustrated.* £2. 2. 0.

This book contains some 8,000 sketches of mechanical movements, machine parts and details, with a short written explanation of how the particular function is accomplished where necessary.

Sketches of related parts are logically grouped for their suggestive value—some idea of the coverage may be gained from the class headings which include fasteners; adjusting devices; supports and structures; basic mechanical movements; elevators, derricks, cranes and conveyors; transmission of liquids and gases; combustion; prime movers; transportation; industrial processes; electrical appliances; heating, cooling and air conditioning. Each of these classes is divided into sections, and each section sub-divided into topics.

621.795 SURFACE PROCESSES: FINISHING

"**Finishing Materials and Methods**", by George A. Soderberg. *Bloomington, Ill., McKnight & McKnight,* 1952. 320 *pages. Illustrated. Diagrams.* $4.00.

The Materials section is devoted to the constituents and manufacture of varnishes; enamels; paints—metallic, luminescent, oil resin emulsions and plastic; stains; removers; coated and polishing abrasives; masking tapes and fire retardants. Illustrations show paint on wood failures with normal and alternatively with aluminium primers.

The methods section deals with brushing, including the manufacture and care of brushes; spraying; tumbling; bleaching; satin and marble finishes; painting of external wood surfaces and metal surfaces including flock application. The operations of taping a wall finished with plasterboard or other wallboard are fully shown. Inlaying silver is an example of several special finishes described. The volume concludes with a chapter on the harmonising of colours and safety measures for personnel and the minimising of fire hazards.

"**Barrel Polishing**" by E. G. West. *Machinery Publishing Co., Brighton,* 1953. 47 *pages, illus., diags.* 4s. (Machinery's Yellow Back Series No. 15.)

The text and illustrations set out to describe the equipment and abrasives used for polishing and scouring in the tumbling barrel.

A small section is devoted to the theory of polishing. Under "abrasives" requirements are given and a comprehensive description of most common materials is listed in such a way that the user can select his materials with ease.

A section is devoted to drying in centrifuges and air drying machines, and the concluding chapter deals with latest developments.

PAPERS RECEIVED

1978: "**An Investigation into Industrial Design and Drawing Practice in New South Wales**" by Sydney Section Working Group.

1980: "**Mould Design for the Production of Thermoplastic Articles by the Injection Moulding Process**" by A. N. Byford.

1983: "**Heavy Armoured Vehicle Fabrication**" by J. W. Brind.

1984: "**Human Factors in Engineering Production**" by J. Munro-Fraser.

1985: "**The Problems of a Managing Director**" by Peter Smith.

1987: "**Surface Finish**" by J. Halling.

1989: "**The Estimating Department and Its Relation to Costing and Cost Control**" by J. G. Hyland.

1990: "**Things I Have Learned from People**" by W. C. Puckey.

OTHER ADDITIONS

621.3 ELECTRICAL ENGINEERING

British Electrical and Allied Industries Research Association, Leatherhead. "**Annual Report No. 32, 1951-2.**" *Leatherhead, Tne Association.*

621.64 HYDRAULIC POWER

Ernst, Walter. "**Oil Hydraulic Power and its Industrial Applications.**" *New York, McGraw-Hill,* 1949. 366 *pages. Illustrated. Diagrams.* £3. 4. 0.

621.0052 AUTOMATIC CONTROLS AND SYSTEMS
Great Britain—Ministry of Supply. **"Servomechanisms."** Issued by the Ministry of Supply; published for the Technical Information and Documents Unit of the D.S.I.R., by *H.M.S.O., London,* 1951. 293 *pages. Illustrated. Diagrams.* £3. 3. 0. (Selected Government Research Reports, Vol. 5.)

621.78 HEAT TREATMENT
Du Pont De Nemours, E. I. & Co. (Inc.)—Electrochemicals Dept., Niagara Falls, N.Y. **"Molten Salt Baths for Heat Treatment and Case Hardening of Steel."** *Niagara Falls, N.Y., the Company,* [n.d.] 78 *pages.*

621.791 WELDING; CUTTING
West, E. G. **"Joining Aluminium: a Summary of Present Practice."** *London, Aluminium Development Association,* 1952. 14 *pages. Illustrated. Diagrams.* (Adhesion, June 1952.)

621.7913 SOLDERING; BRAZING
American Platinum Works—Research Division, Newark, N.J. **"Complete Guide to Successful Silver Brazing."** *Newark, The Firm,* 1953. 46 *pages. Illustrated. Diagrams.*
Arbib, Richard. **"Considerations of Soldering Technique in Radio and Television Assembly."** *Hemel Hampstead, Herts, Multicore Solders Ltd.,* 1953. 6 *pages. Illustrated.*

PERIODICALS CURRENTLY RECEIVED

Aero Research Technical Notes. Duxford, Cambridge.
Aircraft Engineering. London.
Aircraft Production. London.
Aluminium Courier. London.
Aluminium News. Montreal.
American Machinist. New York.
Applied Hydraulics. Cleveland.
Aslib Book-list. London.
Aslib Information. London.
Aslib Proceedings. London.
Association Française des Conseils en Organisation Scientifique. Paris. [Bulletin] mensuel.
Au tin Technical News. Birmingham.
Automobile Engineer. London.

B.S.C.R.A. Abstracts. Sheffield.
B.S.F.A. Bulletin. Sheffield.
Bacie Journal. London.
Bacie Visual Aids Bulletin. London.
Ball Bearing Journal. Luton.
Beama Journal. London.
Bearing Engineer. New York.
Bibliographia Scientiae Naturalis Helvetica. Berne.
Bibliography of Industrial Diamond Applications. London.
Bibliotech. Birmingham.
Bonderizer. Brentford.
Books of the Month. London.
British Cast Iron Research Association. Birmingham. Bulletin and Foundry Abstracts.
British Institute of Management. London. Library Bulletin.
British Institution of Radio Engineers. London. Journal.
British Machine Tool Engineering. London.
British Management Review. London.
British Non-Ferrous Metals Research Association. London. Bulletin.
British Packer. London
British Plastics. London.
British Standards Institution. London. British Standards.
British Standards Institution. London. Monthly Information Sheet.
British Standards Yearbook. London.
Business. London.

C.N.O.F. Paris.
Centre de Documentation Sidérurgique. Paris.
Bulletin Analytique.
Circulaire d'Informations Techniques.
Chartered Civil Engineer. London.
Compressed Air Engineering. London.
Copper Development Association. Radlett, Herts. Technical Survey.
Cost Accountant. London.
Cronache Della Produttività. Rome.

Design News. Grand-Rapids, Mich.
Director. London.
Doelmatig Bedrijfsbeheer. Alphen aan den Rijn.
Drawing Office Announcer. London.

Economist. London.
Edgar Allen News. Sheffield.
Electrical Journal. London.
Electrical Manufacturer. London.
Electrical Review. London.
Electronic Application Bulletin. Eindhoven.
Elliott Journal. London.
Engineer. London.
Engineer & Foundryman. Johannesburg.
Engineer Apprentice and Engineer Student. London.
Engineering. London.
Engineering Index. New York.
Engineering Industries Association Bulletin. London.
Engineering Journal. Montreal.
Engineers' Digest. London.
English Electric Journal. Stafford.
Esso Oilways. London.
Etude du Travail. Paris.

Factory Management and Maintenance. New York.
Factory Manager. London.
Fasteners. Cleveland.
Flow. Cleveland.
Foundry Trade Journal. London.
Furniture Development Council. London. Technical Bulletin
Future. London.

G.E.C. Journal. London.
Government Publications: Consolidated List. London.
Government Publications: Monthly List. London.
Great Britain—*Directorate of Aircraft Production Development.* Extracts from D.A.P.D. Progress Reports for Issue to Industry. London.
Great Britain—*Ministry of Labour and National Service.* Information Service for Editors of Trade and Technical Journals. London.
Grits and Grinds. Worcester, Mass.

Haynes Alloys Digest. International Edition. New York.
Heating and Air Treatment Engineer. London.
Hiduminium Abstract Bulletin. Slough.
Hommes & Techniques. Paris.

Index Aeronauticus. London.
Indian & Eastern Engineer. Calcutta.
Industrial Diamond Review. London.
Industrial Welfare and Personnel Management. London.
Informes de la Construccion. Madrid.
Institute of British Foundrymen. Manchester. Proceedings.

Institute of Marine Engineers. London. Transactions.
Institute of Metal Finishing, incorporating Electrodepositors' Technical Society. London. Bulletin.
Institute of Metal Finishing, incorporating Electrodepositors' Technical Society. London. Transactions.
Institute of Road Transport Engineers. London. Journal and Proceedings.
Institute of the Motor Industry. London. Journal.
Institute of Welding. London. Transactions.
Institution of Automotive and Aeronautical Engineers. Melbourne. Journal.
Institution of Civil Engineers. London. Proceedings.
Institution of Electrical Engineers. London. Proceedings, Part I, General.
Institution of Engineers & Shipbuilders in Scotland. Glasgow. Transactions.
Institution of Engineers, Australia. Sydney. Journal.
Institution of Heating and Ventilating Engineers. London. Journal.
Institution of Mechanical Engineers. London. Journal. Proceedings.
Institution of Mechanical Engineers.—*Automobile Division*. London. Proceedings.
Institution of Production Engineers. London. Journal.
Instituto Tecnico de la Construccion y del Cemento. Madrid. [Monographs].
Instrument Engineer. Luton.
Irish Engineering Journal. Dublin.
Iron Age. Philadelphia.
Iron & Coal Trades Review. London.
Iron and Steel Institute. London. Journal.

Journal of Documentation. London.
Junior Institution of Engineers. London. Journal.

Leeds Association of Engineers. Leeds. Annual Report and Journal.
Liège International Fair. Bulletin.
Light Metals Bulletin. London.
Lubrication. New York.

Machine and Tool Blue Book. Wheaton, Illinois.
Machine Design. Cleveland.
Machine Shop Magazine. London.
Machine-Tool Review. Coventry.
Machinery. London.
Machinery. New York.
Machinery Lloyd. London.
Machinery Market. London.
Machinist. London.
Management Abstracts. London.
Management Digest. Adelaide.
Management News. Sydney.
Management Review. New York.
The Manager. London.
Marketing. London.
Mass Production. London.
Materials & Methods New York.
Mechanical World and Engineering Record. Manchester and London.
Mécanique Documentation. Paris.
Mechanical Handling. London.
Metal Industry. London.
Metal Treatment and Drop Forging. London.
Metal-Working. White Plains, New York.
Metallurgical Abstracts. London.
Metropolitan-Vickers Electrical Company Ltd. Manchester. Technical News Bulletin.
Mill & Factory. New York.
Modern Machine Shop. Cincinnati.
Motion Economy. Cheadle, Cheshire.
Murex Review. Rainham, Essex.

New Technical Books. New York.
New Zealand Engineering. Wellington.
Nickel Bulletin. London.
North East Coast Institution of Engineers & Shipbuilders. Newcastle-upon-Tyne. Transactions.

O.R.: Operational Research Quarterly. London.
Occupational Psychology. London.
Office Management. London.
Ohio State University Studies, Engineering Series. Columbus, Ohio.
Oil. London.
Oil Lifestream of Progress. New York.

PERA Bulletin. Melton Mowbray.
Personnel Management. London.
Personnel Management Welfare and Industrial Equipment. London.
Philips Technical Review. Eindhoven.
Physics Abstracts. London.
Polish Technical Abstracts. Warsaw.
Polytechnical Weekly Magazine. Amsterdam.
Power Transmission. London.
Precision Metal Molding. Cleveland.
Product Engineering. Albany, New York.
Product Finishing. London.
Production Efficiency. London.
Produttivita. Rome.

Refa Nachrichten. Darmstadt.
Report. Dorking.
Report from Cincinnati Milling. Cincinnati, Ohio.
Revista de Ciencia Aplicada. Madrid.
Revue Générale des Sciences Appliquées. Brussels.
Reynolds Metals Technical Advisor. Louisville, Ky.
Rivista di Meccanica. Milan.
Rotol and British Messier Digest. Gloucester.
Royal Aeronautical Society. London. Journal.
Royal Institute of Technology. Stockholm. Transactions.
Rubber Developments. London.

Science & Engineering. Calcutta.
Scientific Lubrication. Wellington, Salop.
Scope. London.
Screw Machine Engineering. Rochester, New York.
Sheet and Strip Metal Users' Technical Association. London. Annual Proceedings.
Sheet Metal Industries. London.
Shell Magazine. London.
South Wales Institute of Engineers. Cardiff. Proceedings.
Swiss Technics. Lausanne.

The Supervisor. Birmingham.
TWI Topics. London.
The Tabulator. London.
Target. London.
Technical Journal of the Brush Group. London.
Textile Institute. Manchester. Journal.
Tijdschrift voor Efficientie en Documentatie. 's-Gravenhage, Holland.
Time and Motion Study. London.
Times Review of Industry. London.
Timken Times and FBC Bulletin. Northampton.
Tool Engineer. Milwaukee, Wis.
Toolmaker & Precision Engineer. London.
Torque. London.
Trait d'Union. Paris.

University of Illinois. Bulletin. Urbana.

V-Belt Journal. Hull.

Welding and Metal Fabrication. London.
Werkstatt und Betrieb. Munich.
Werkstattstechnik und Maschinenbau. Berlin.
Whitaker's Cumulative Book List. London.
Wiggin Nickel Alloys. Birmingham.
Woman Engineer. London.
Works Management. London.

Z.D.A. Abstracts. Oxford.
Zinc Bulletin. Oxford.

NOTICE OF ANNUAL GENERAL MEETING

Notice is hereby given that the Annual General Meeting of the Institution will be held at 36, Portman Square, London, W.1, on Thursday, 28th January, 1954, at 11.0 a.m.

AGENDA

1. Notice convening Meeting.
2. Minutes of the Annual General Meeting held on 29th January, 1953, and of the Extraordinary General Meeting held on 17th September, 1953.
3. To transact the following business:—
   The Vice-Chairman of Council, Mr. G. R. Pryor, will propose
   "that new Articles of Association as set out on pages 56 to 62 following, be and are hereby adopted"
4. Report on Election of Members to Council (1).
5. Annual Report of Council (2).
6. Presentation of Statement of Income and Expenditure, Balance Sheet and Auditors' Report (3).
7. Election of Auditors, 1953/54.
8. Election of Solicitors, 1953/54.
9. Votes of Thanks.

By Order of the Council,
W. F. S. WOODFORD, *Secretary.*

1. See page 62.
2. See pages 63/69.
3. See pages 70/72.

MINUTES OF THE ANNUAL GENERAL MEETING HELD ON THURSDAY, 29TH JANUARY, 1953

THE Thirty-first Annual General Meeting of the Institution was held on Thursday, 29th January, 1953, at 4 p.m., at the Headquarters of the Institution, 36, Portman Square, London, W.1. The President, Sir Cecil Weir, K.C.M.G., K.B.E., M.C., D.L., was in the Chair.

Notice Convening Meeting

The Secretary (Mr. W. F. S. Woodford) read the Notice convening the Meeting.

Minutes of previous Annual General Meeting

The Minutes of the previous Annual General Meeting held on 23rd January, 1952, were taken as read and confirmed, on the motion of Mr. T. Fraser, C.B.E., seconded by Mr. J. E. Hill.

Election of Members to Council

The Report on the Election of Members to Council was received on the motion of Mr. W. P. Kirkwood, seconded by Mr. G. E. C. Gilfillan, O.B.E.

Annual Report of Council

The Chairman of Council (Mr. H. Burke), in moving the adoption of the Annual Report of Council, said that with the permission of the meeting he would take the Report as read. He drew attention to and read some of the more important items which it contained, and paid tribute to the members who had assisted him since he had taken office as Chairman of Council. His predecessor, Mr. Puckey, had set a high standard during his period of office but he was doing his best to uphold this high standard. He could think of no member of the Institution who had contributed more to its progress than Mr. Puckey had done. Mr. Burke also expressed thanks to the Vice-Chairman of Council, Mr. G. R. Pryor, for his able assistance. Thanks were also due to the members of Council and various Committees throughout both this country and the Commonwealth.

Council were extremely sorry that Sir Cecil Weir had decided not to continue in office as President for a second year, because there was no doubt that he had had a profound influence upon the thinking of the senior officers of the Institution. He wished also to pay tribute to the Past President, Major-General K. C. Appleyard, C.B.E., on behalf of members of the Institution and to thank him for his years of service in which he had set an example which had commanded admiration from all Sections. He also thanked the staff at Head Office, who, working together with enthusiasm for the common cause of the Institution, were a first-class team. The Institution were very fortunate to have such a staff.

The President, Sir Cecil Weir, thanked the Chairman of Council for his Annual Report. In associating himself with the remarks concerning Mr. Puckey, he said that the Institution had every reason to be proud

of the work which had been reported upon, and the progress which had been made. He wished also to be associated with the tribute to members of the staff at Headquarters.

Statement of Income and Expenditure, Balance Sheet and Auditors' Report

The Chairman of Council moved the adoption of the Accounts. The motion was seconded by Mr. E. Percy Edwards, and carried unanimously.

Election of Auditors, 1952/53

On the motion of Mr. J. E. Hill, seconded by Mr. G. R. Pryor, Messrs. Gibson, Appleby & Co., Chartered Accountants, were re-elected Auditors to the Institution and thanked for their services.

Election of Solicitors, 1952/53

Mr. E. Percy Edwards moved that Messrs. Syrett & Sons be re-elected Solicitors to the Institution and that they be thanked for their services. Mr. H. G. Gregory seconded the motion which was carried.

The proceedings then terminated.

MINUTES OF AN EXTRAORDINARY GENERAL MEETING SUMMONED FOR THURSDAY, 10TH SEPTEMBER, 1953, AND ADJOURNED UNTIL THURSDAY, 17TH SEPTEMBER, 1953

AN Extraordinary General Meeting of the Institution was summoned to be held at 36, Portman Square, London, W.1, on Thursday, 10th September, 1953, at 3 p.m. As a quorum was not assembled by 3.30 p.m. the Chairman of Council, Mr. H. Burke, declared the meeting adjourned for seven days at the same time and place, in accordance with Articles of Association, No. 56.

The Adjourned Extraordinary General Meeting of the Institution was held at 36, Portman Square, W.1, on Thursday, 17th September, 1953. Mr. W. Puckey, President of the Institution, was in the Chair.

Notice Convening Meeting

The Secretary (Mr. W. F. S. Woodford) read the notice convening the meeting.

Mr. Harold Burke (Chairman of Council) moved: "that the Council of the Institution be empowered to borrow from the Westminster Bank Limited up to a limit of £25,000 by way of overdraft from time to time secured against the Institution's Stock Exchange Securities already held by the Westminster Bank Limited, Park Lane branch and, if necessary, against the Title Deeds on No. 10, Chesterfield Street, London, W.1, which the Institution undertakes to deposit with the Bank and that the Chairman of Council and the Secretary be empowered to sign the form of Charge".

The motion, having been formally seconded by Mr. Greathead, was put to the meeting and carried unanimously.

The proceedings then terminated.

Index to ARTICLES OF ASSOCIATION on following pages

ARTICLES OF ASSOCIATION OF THE INSTITUTION OF PRODUCTION ENGINEERS

To be adopted by special resolution at an Extraordinary General Meeting to be held on January 28th, 1954.

THE COMPANIES ACT, 1948.
COMPANY LIMITED BY GUARANTEE AND NOT HAVING A SHARE CAPITAL.

PRELIMINARY

1. In these Articles:—

"The Act" means the Companies Act, 1948.

When any provision of the Act is referred to, the reference is to such provision as modified by any statute for the time being in force. Wherever the male gender is used it shall be taken also to refer to the female gender.

Unless the context otherwise requires, expressions defined in the Act or any statutory modification thereof in force at the date at which these Articles become binding on the Institution, shall have the meanings so defined.

2. For the purpose of registration, the number of members of the Institution was declared not to exceed 1,000 but the Council may at any time register an increase in the number of members.

3. The Institution is established for the purpose expressed in the Memorandum of Association.

4. The Institution's financial year shall run from the 1st July to the following 30th June. Where the term "year" is used in these Articles or in connection with any other business of the Institution it shall, unless otherwise stated, be deemed to refer to a period from 1st July to 30th June.

5. All elected officers, members of Council and members of Committees, shall take up office on the 1st July following the date of their election, except in the case of those elected to fill casual vacancies, who shall take up office immediately upon election.

MEMBERSHIP

Definition

6. A production engineer is one who, by reason of education, training and experience in technology and management, is competent to determine the factors involved in the manufacture of commodities and to direct the production processes to achieve the most efficient co-ordination of effort, with due consideration of quantity, quality and cost.

Preliminary

7. The Institution of Production Engineers (herein called "The Institution") shall consist of Honorary Members, Members, Associate Members, Associates, Affiliated Organisations, Graduates and Students, of whom Honorary Members, Members and Associate Members shall be called corporate members. The use of the words "members" or "membership" in these Articles shall include all the foregoing. The use of the word "Member" (with a capital M) shall refer to the grade of Member, but the use of the word "member" (with a small m) shall refer to all grades of membership.

8. No member shall be entitled to any privileges other than those which these Articles attach to the specific grade of member of the Institution to which he belongs.

9. The Subscribers to the Memorandum of Association were the first members of the Institution. In addition to any persons who were members at the date of the adoption of these Articles the Council may admit to membership such persons as may be qualified, as hereinafter defined, and make application in the form and manner prescribed by the Council.

10. The rights and privileges of every member shall be personal to himself, and shall not be transferable or transmissible by his own act or by operation of law.

Abbreviated Titles

11. The abbreviated distinctive titles to indicate the various grades of membership shall be as follows: For an Honorary Member, Hon.M.I.Prod.E.; for a Member, M.I.Prod.E.; for an Associate Member, A.M.I.Prod.E.; for an Associate, A.I.Prod.E.; for a Graduate, Grad.I.Prod.E.; for a Student, Stud.I.Prod.E.

Such abbreviations may not be used by any member who has resigned or whose name has been removed from the Institution's register, nor may they at any time be used upon any shop front, fascia or sign. If used upon door or wall plates, the abbreviations shall not exceed 1½ ins. in height.

Certificates

12. The Council shall issue hereafter to every member (except Students) on election a Certificate showing the grade of membership to which he is elected. Every such Certificate shall remain the property of, and shall on demand be returned to, the Institution.

Qualifications for Membership

Honorary Members

13. The Council shall have the power to elect as Honorary Members those who, by reason of their special services to the Institution or to production engineering generally or by virtue of their occupying distinguished positions in science or industry, merit such recognition.

Members

14. Candidates for admission to the grade of Member must be persons who have by their attainments acquired an established reputation as production engineers, as defined in Article 6, and have produced evidence to the satisfaction of the Council, either:—

(a) That they, being not under 33 years of age and already Associate Members, have been engaged for a sufficient period in an important position of responsibility in production engineering.

(b) That they, being not under 35 years of age and possessing the qualifications for Associate Membership, have in addition been engaged for a sufficient period in an important position of responsibility in production engineering.

(c) That they, being not under 40 years of age, are by their attainments deemed by the Council to be eligible and desirable for membership as Members.

Associate Members

15. Candidates for admission to the grade of Associate Member must be persons not under 28 years of age and must produce evidence to the satisfaction of the Council that they:—

(a) Have received a good general education and adequate practical training in production engineering.

(b) Have for not less than four years been engaged in the practice of production engineering and have, for a sufficient period, held a position of responsibility in production engineering; provided that those engaged in the teaching of production engineering up to standards acceptable to the Council shall be deemed to have satisfied the requirements of this Clause.

(c) Have passed the Associate Membership Examination prescribed by the Council's examination regulations for the time being or such other exempting examinations as may from time to time be approved by the Council; provided that candidates over the age of 35 who have not passed one of the above mentioned examinations may be required to pass only such part or parts of the Associate Membership Examination or to submit such Theses as the Council shall direct.

Associate Members may, on attaining the necessary age and qualifications, make application to be transferred to the grade of Member.

Associates

16. Candidates for admission to the grade of Associate must be persons not under 28 years of age who, although not possessing the qualifications for corporate membership, nevertheless possess qualifications of a comparable standard in related professions and, in addition, have held for a sufficient period positions of authority involving managerial responsibility for, or control of, functions pertaining to production engineering.

Associates may, on attaining the necessary qualifications, apply for transfer to corporate membership.

Affiliated Organisations

17. Affiliated Organisations shall be incorporated organisations interested in production engineering and desirous of subscribing to the Objects of the Institution and approved by resolutions of the Council as Affiliated Organisations.

Affiliated Organisations may nominate as their representatives such persons as may be approved by the Council, but these representatives shall not, by virtue of being such representatives, become members of the Institution or be entered in the register of members.

Graduates

18. Graduates must be persons not under 21 years of age who can produce evidence to the satisfaction of the Council that they are receiving or have received adequate practical training in production engineering and have passed such parts of the Institution's Associate Membership Examination as may be prescribed by the Council's examination regulations for the time being or such other exempting examinations as may from time to time be approved by the Council.

No person over the age of 30 years shall be elected as a Graduate except by special resolution of the Council. Graduates, on attaining the age of 28 years and having such other qualifications as may be necessary, may apply for transfer to higher grades of membership, but may not continue as Graduates beyond the age of 35 years, except by special resolution of the Council.

Students

19. Students must be persons not under 18 years of age who can produce evidence to the satisfaction of the Council that they have received a good general education and are following a form of practical training and technical education approved by the Council. No person over the age of 25 years may be elected as a Student, except by special resolution of the Council.

Students, on attaining the age of 21 years and having such other qualifications as may be necessary, may apply for transfer to Graduate Membership, but no person may remain a Student after attaining the age of 28 years, except by special resolution of the Council.

Election of Members

20. Elections of members shall take place as often as may be desirable and they shall be made by the Council.

21. All those admitted to the Institution, whether as Honorary Members, Members, Associate Members, Associates, Affiliated Organisations, Graduates or Students, shall be considered as belonging thereto, until their names shall have been removed by the Institution from its register.

22. The Council shall cause successful candidates to be notified of their election, but the names of the candidates shall not be entered in the register of members until such entrance fees and subscriptions as may be prescribed by the Council have been paid. Failure to pay such fees and subscriptions within three months of notification will nullify the election of the candidate.

23. In the case of non-election, no mention thereof shall be made in the Council minutes.

Transfers

24. Transfers of any members to other grades of membership approved by the Council shall become complete upon payment by the member of any difference there may be in subscription.

25. In the case of non-transference, no mention thereof shall be made in the Council minutes.

Resignation and Expulsion

26. Any member, on sending written notice to the Registered Office that he is desirous of withdrawing from the Institution, shall cease to be a member and his name shall be removed forthwith from the register of members.

27. If any member shall leave his subscription in arrear for one year, and shall fail to pay such arrears within three months after a written application has been sent to him to his last known address, his name may be struck off the register pursuant to a resolution by the Council in that behalf at any time afterwards, and he shall thereupon cease to be a member.

No member whose subscription is more than twelve months in arrear shall be entitled to attend or take part in the meetings of the Institution, or to enjoy or exercise any of the privileges of membership; provided always that the Council is free, at its discretion in specific cases, to waive the enforcement of this provision.

28. The Council may, by a resolution passed at a meeting of the Council at which at least two-thirds of the members thereof present and voting vote in favour of the resolution, refuse to continue to receive the subscriptions of any member of the Institution who is not, in the opinion of the Council, a suitable person to continue as such, and may remove his name from the register and he shall thereupon cease to be a member; provided that no such resolution shall be passed or have any operation or effect unless the member affected has been given reasonable notice of the meeting and a proper opportunity of being heard in his defence thereat.

29. No member shall abuse his connection with the Institution to further his business interests. Anyone being adjudged by the Council to have contravened this Article is liable to be removed from the register. The provisions of Article 28 shall *mutatis mutandis* apply to a removal under this Article.

Entrance Fees and Subscriptions

30. The entrance fees and subscriptions for each grade of membership shall be from time to time recommended by the Council, and determined by the Institution by resolution of a General Meeting called for the purpose.

31. All subscriptions shall be payable in advance and shall become due on 1st July in each year. The Council may, at

its discretion, in special circumstances, reduce or remit the annual subscription or the arrears of annual subscription of any member. Those members whose subscriptions have been reduced or remitted under the provisions of this Article shall be entitled to receive Ballot Papers, Certificates, Publications and Notices of the Institution as if their subscriptions had been paid in full, but the Council may impose such other conditions as may seem necessary according to the circumstances.

32. All members elected in the last six months of any year shall pay, in addition to any entrance fee that may apply to their grade of membership, one half of the annual subscription to secure their membership for the remainder of the year of election.

33. Any Member, Associate Member or Associate whose subscription is not then in arrear may compound for the then current year and all future years by the payment of such amount as may be determined in accordance with Article 30.

COUNCIL

Composition of Council

34. The Council of the Institution shall be chosen from Honorary Members, Members and Associate Members only and may not consist of more than one President; two Vice-Presidents; one Chairman of Council; one Vice-Chairman of Council; the immediate Past Chairman of Council; Presidents of Sub-Councils outside the United Kingdom or Chairmen of Sections outside the United Kingdom where Sub-Councils do not exist; Chairmen (or their elected representatives) of United Kingdom Regions; one Additional Representative for each United Kingdom Region with more than 750 members, such Additional Representative to be elected in accordance with Article 55; eighteen elected members of Council, two of whom shall be Associate Members; and two co-opted members in addition to co-options under Article 35. All Chairmen of Standing Committees shall during their respective terms of office be *ex officio* members of the Council. All Past Presidents of the Institution shall be Honorary Members of Council without voting rights.

Co-option

35. The Council shall have the power to co-opt as additional members of Council not more than three persons, who shall be nominated by any other Society, Corporation or Body which has kindred interests with or furthers the objects of the Institution; provided that persons so co-opted shall not be entitled to vote at Council Meetings.

Casual Vacancies

36. The Council shall have the power to fill by co-option any casual vacancies that may occur through the death or resignation of any Councillors. Councillors so co-opted shall retire at the end of the year in which they were co-opted.

37. The continuing members of the Council may act notwithstanding any vacancies in the Council; provided that if the number of members of the Council shall be reduced below fifteen, the continuing members may act for the purpose of filling vacancies in their body or of summoning a General Meeting, but for no other purpose.

38. A member of the Council shall vacate his office if he becomes bankrupt or of unsound mind or resigns his office by notice in writing to the Institution, or if he ceases for any cause to be a member of the Institution, or if he ceases to hold office by virtue of Section 185 of the Act or by a resolution passed pursuant to Section 184 of the Act or becomes prohibited from acting by any order made under Section 188 of the Act.

Principal Officers

39. At the last meeting in each year, the Council shall elect a President of the Institution for the ensuing Session; not more than two Vice-Presidents who may be future Presidents; and from amongst the present and past members of the Council the Chairman of Council and a Vice-Chairman of Council for the ensuing Session. These Officers shall be known as the Principal Officers. The Chairman and Vice-Chairman so elected shall be empowered to perform any function of the President or Vice-Presidents of the Institution, should the holder of that office or the holders of the office of Vice-President desire to delegate all or any of their functions.

40. Candidates for the offices of President and Vice-Presidents shall be nominated by a member of Council at or before the Council Meeting prior to that at which the election of President and Vice-Presidents takes place.

Duration of Office

41. All the principal officers shall retire at the end of one year of office; they shall be eligible for re-election but they may not serve for more than two consecutive years in any one office, except that the Vice-Presidents may continue in office as such until their election as President, or for a period not exceeding four years. Nine elected members of Council, one of whom shall be an Associate Member, shall retire each year and may not be re-elected in that capacity until at least one year has elapsed, those to retire being those who have been longest in office since the date of their last election; if there are more than eight Members or one Associate Member with equal seniority, the retiring members shall be chosen from amongst their number by the drawing of lots. Those members co-opted under the provisions of Article 34 shall retire at the end of the year in which they were co-opted.

Meetings of the Council

42. The Council shall meet at least four times a year, at a time and place to be determined by the Council and only members of the Council shall be entitled to receive notice of or to attend meetings of the Council, unless visitors have been specifically invited by the Council. Provided that three members of the Council may and, on the request of three members of the Council the Secretary shall, at any time summon a meeting of the Council by notice served upon the members of the Council. Council members shall be given at least seven days notice in writing of meetings of the Council. If neither the Chairman nor the Vice-Chairman of Council is present within fifteen minutes of the time for which the meeting was called, the Council may elect any one of their members to take the Chair for that meeting only.

Elections to the Council

43. An election to fill vacancies on the Council shall be held annually in May. Candidates for election as Councillors, except candidates nominated by Section Committees, must be nominated in writing by three Members or Associate Members. Each Section Committee may nominate one candidate.

Notice of the election shall be forwarded to all corporate members at least ten days prior to the latest date fixed for receiving nominations, together with notification of the number of vacancies to be filled. Within three weeks after the latest date for receiving nominations, a ballot paper shall be forwarded to all corporate members. The ballot paper shall contain the names, business and private addresses, occupations and honorary titles of the candidates and the names of the members or Section Committee by whom they are nominated. Those elected as Principal Officers for the ensuing year, together with the Chairmen of United Kingdom Regions and the Additional Representatives of the United Kingdom Regions if any, shall not be subject to ballot by corporate members; but the names, addresses, titles, etc., of those so elected, together with the names of the non-retiring Councillors shall be sent to the members with the ballot paper. Corporate members shall vote for as many candidates as there are vacancies to be filled, in accordance with the instructions on the ballot paper, determined from time to time by the Council. Only

those votes shall be effective which are recorded on ballot papers reaching the Institution's Auditors by a specified date, which shall be a date not less than one week or more than two weeks after the ballot papers have been issued.

Proceedings, Powers and Duties of the Council

44. The Council shall direct and manage the property and affairs of the Institution, and may regulate their own procedure, except that (unless and until otherwise determined by the Council), fifteen Councillors shall form a quorum. Questions arising at a meeting of the Council shall be determined by a majority of those present and voting, except that resolutions involving proposals to alter the Articles of Association shall not be carried unless two-thirds of the Council members present and voting shall vote in favour of the resolution, except as otherwise provided for in these Articles. At meetings of the Council, every member of Council shall have one vote. In the case of an even number of votes for and against a resolution, the Chairman shall have a second or casting vote. The Council may exercise all such powers of the Institution and do on behalf of the Institution all such acts as may be exercised and done by the Institution, and as are not by the statutes or by these presents required to be exercised or done by the Institution in General Meeting. No regulation made by the Institution in General Meeting shall invalidate any prior act of the Council which would have been valid if such regulation had not been made; provided that the Council may not, without the authority of a resolution of the Institution in General Meeting, borrow monies for the purposes of the Institution on the security of the property of the Institution or other available security.

45. The Council shall have power to appoint Standing Committees or Temporary Committees to deal with such matters as the Council may deem necessary and may delegate authority to such Committees. The terms of reference, constitution, powers and duties of each Standing or Temporary Committee shall be laid down from time to time by the Council. The Chairman of each Standing Committee shall be *ex officio* a member of the Council. The Chairmen of Standing Committees shall retire at the end of one year of office; they may be re-elected for a second year, but may not serve for more than two consecutive years in that capacity.

All corporate members shall be eligible for service on Standing or Temporary Committees

The Principal Officers shall be ex-officio members of all Standing or Temporary Committees.

Committees shall be elected by the Council and shall consist respectively of (a) members and (b) others, provided that those elected under (b) shall never exceed one-third of the total number of members of any Committee. Such Committees shall be subject to re-election annually.

46. Technical Groups or Specialist Divisions may be formed by the Council at its discretion, if sufficient evidence is produced of the demand for the formation of such Groups or Divisions, subject to any conditions that the Council may specify, and the Technical Group or Specialist Division may elect a Chairman and Committee.

47. The Council shall have power to dissolve or suspend any Standing or Temporary Committee or Technical Group or Specialist Division at any time after it has been formed, or remove any member thereof.

48. It shall be the duty of the Council to adopt all due means for the advancement of the Institution; to provide for properly conducting its business in all cases of emergency; and to arrange for the publication, in such a way as they may deem desirable, of the papers read at meetings of members of the Institution, and discussions thereon, and of such documents as may be calculated to advance production engineering knowledge.

49. No act done by the Council, whether *ultra vires* of the Council or not, which shall have received the sanction of a General Meeting, shall be afterwards impeached by any person included in the membership of the Institution on any ground whatever, but shall be deemed to be an act of the Institution, provided that, though *ultra vires* of the Council, it be within the powers of the Institution.

50. All acts done by any meeting of the Council or a Committee or by any person acting as a member of the Council shall, notwithstanding that it be afterwards discovered that there was some defect in the appointment or continuance in office of any such body or person acting as aforesaid or that they or any of them were disqualified, be as valid as if every such body or person had been duly appointed or had duly continued in office and been qualified.

Kindred Associations

51. The Council may arrange for the union or alliance with the Institution of any society with kindred objects and not formed for profit and may also if they think fit remit or reduce the entrance fees of any members of any such society who become members of the Institution, provided that such proposed union or alliance shall be ratified by a postal ballot of the whole corporate membership of the Institution, in which a majority of the members shall vote in favour of the proposal.

Sub-Councils outside the United Kingdom

52. The Council shall have power to authorise the election of Sub-Councils in any Territories outside the United Kingdom where Sections are established and may delegate authority to Sub-Councils to carry out their affairs in accordance with the rules and regulations laid down by the Council.

The Seal

53. The Seal of the Institution shall not be affixed to any instrument except by the authority of a resolution of the Council, and, in the case of all instruments other than membership certificates, in the presence of a member of Council, and of the Secretary or other such person as the Council may appoint for the purpose; and that member of Council and the Secretary or other person as aforesaid shall sign every instrument (other than membership certificates) to which the Seal of the Institution is so affixed in their presence.

UNITED KINGDOM REGIONS

54. All Local Sections established in the United Kingdom in accordance with the provisions of Article 59 shall be grouped into twelve Regions and the boundaries of each Region shall be as determined from time to time by the Council.

55. A Committee for each Region shall be appointed from the members of the constituent Local Section Committees, as prescribed in Article 62. The Regional Committee thus appointed shall carry on the affairs of the Region in accordance with rules and regulations laid down from time to time by the Council. They shall elect a Regional Chairman from among the Members in the Region, who shall upon such election become a member of the Council. Each Region with more than 750 members shall elect from among the members of the Regional Committee, by ballot of the corporate members in the Region, an Additional Representative to serve on the Council. The Regional Committee shall also elect a Regional Honorary Secretary and a Regional Honorary Treasurer from among the members in the Region and these officers shall become members of the Regional Committee upon election, subject to the approval of the Council in each case and provided that these officers, if they are not corporate members, shall not have power to vote. The Regional Committee shall have power to co-opt as additional members of the Regional Committee not more than two members in the Region, provided that if such co-opted members are not corporate members of the Institution, they shall not have power to vote.

56. It shall be the duty of the Regional Committee to organise activities within the Region other than the activities of Local Sections; to co-ordinate the programmes and activities of the constituent Local Sections; to recommend to the Council the establishment of new Local Sections within the Region; to allocate equitably amongst the constituent Local Sections of the Region such funds as may be allocated by the Council to the Regions for this purpose; and to implement within the Region the policy of the Institution, as determined from time to time by the Council.

57. The Regional Chairman shall retire at the end of one year of office; he shall be eligible for re-election for a second year, but may not serve for more than two consecutive years in that capacity. A corporate member of a Region elected to serve on the Regional Committee when the Section Honorary Secretary is not a corporate member shall retire at the end of one year of office; he may be re-elected for a second year, but he may not serve for more than two consecutive years in that capacity. The Section Additional Representatives on the Regional Committee shall retire at the end of one year of office; they may be re-elected for a second year, but they may not serve for more than two consecutive years in that capacity. The Regional Honorary Secretary and the Regional Honorary Treasurer shall retire each year and they shall be eligible for re-election. Co-opted members of the Regional Committee shall retire at the end of the year in which they are co-opted. The election of Regional Officers for the ensuing year shall be held in April each year.

58. The appropriation and contribution of funds of the Institution towards the expenses of United Kingdom Regions and of Sub-Councils and Sections outside the United Kingdom shall be at the sole discretion of the Council and the Institution shall not be responsible for any liability incurred by or on behalf of any Local Section or United Kingdom Region of the Institution beyond any amount previously appropriated or contributed for any such specific purpose by the Council.

LOCAL SECTIONS

59. Local Sections of the Institution may be formed by the Council in such centres as afford evidence satisfactory to the Council, on the recommendation of a Regional Committee as provided for in article 56:—

(a) Of a demand for the formation of a Local Section on the part of Members and Associate Members resident in the locality, and

(b) That a Local Section, if formed, will be so adequately supported and of such usefulness in the locality that the Regional Committee will be justified in appropriating funds of the Institution towards its support.

These Sections shall consist of members of the Institution. The Council shall have power to dissolve such Sections at any time.

60. The proposal for the formation of a Local Section shall be by petition of the corporate members resident in the locality or otherwise at the discretion of the Council. Such petition, together with the evidence as to the probable support and usefulness of the proposed Section, shall be brought before and considered by the Council, and if they decide that the Section shall be formed, a first meeting of the members resident in the locality shall be convened by written notice specifying generally the nature of the business to be transacted. This meeting shall be under the Chairmanship of a member of Council, who shall be appointed by the Council.

61. A Chairman of a Section (chosen from the Members only) and a Committee of not less than six and not more than eighteen corporate members shall be appointed by resolution of the corporate members on the register of the Section at the first meeting of the Section. The Chairman and Committee shall manage the local affairs of the Section, subject to the approval of the Council and shall elect a Section Honorary Secretary, subject to the approval of the Council. The Chairman and Honorary Secretary of a Graduate Section formed in accordance with Article 64 shall also be additional members of the Local Section Committee, provided that if they are not corporate members they shall not have power to vote. The Local Section Committee elected in accordance with the foregoing may co-opt not more than two additional members to the Committee from among the members of the Section.

62. The Chairman and one-third of the Committee shall retire by rota at the end of each year, they shall be eligible for re-election except that the Section Chairman shall not hold office in that capacity for more than two consecutive years. Casual vacancies in the office of Chairman or in the Committee may be filled by the Committee. The Section Chairman shall be elected by vote of the corporate members of the Section in General Meeting. The Section Honorary Secretary shall retire at the end of each year and shall be eligible for re-election. Co-opted members shall retire at the end of the year in which they are co-opted. The Section Chairman and the Section Honorary Secretary shall, on election, become members of the Regional Committee, except that if the Section Honorary Secretary is not a corporate member, he shall not have power to vote on the Regional Committee, in which case the Section Committee may elect a corporate member from among their number to serve on the Regional Committee. In addition to the Section Chairman and the Section Honorary Secretary and other corporate member when the Section Honorary Secretary is not a corporate member, the Section Committee shall elect from amongst their number to serve on the Regional Committee two additional representatives for the first five hundred members in the Section and one additional representative for each five hundred members beyond the first five hundred.

63. Each Local Section shall be constituted and its affairs shall be carried on in accordance with rules and regulations laid down from time to time by the Council, and the election of officers for the ensuing year shall be held not later than March each year.

64. A Local Section Committee may, if it considers it desirable, propose to the Council through the Regional Committee, the establishment of a Graduate Section within the area of the Section as defined by the Council. A Graduate Section so established by the Council shall elect a Committee which will operate under the general supervision of the Section Committee for its area, and shall be subject to such rules and regulations as may be laid down from time to time by the Council.

OFFICERS

Trustees and Treasurer

65. The Council may appoint Trustees, who shall carry out their duties as laid down by these Articles. The Treasurer of the Institution shall be appointed by the Council and shall be removable by the Council upon three months' notice from any day, but in the case of serious negligence may be dismissed without notice. The Treasurer shall give three months' notice in the event of his wishing to resign.

66. The Treasurer shall hold and be responsible for the uninvested funds of the Institution; shall keep all the accounts necessary and proper for the purpose of the Institution; shall from time to time submit financial statements at the request of the Council; and shall pay all monies into a Bank, approved by the Council, upon receipt.

Secretary

67. The Secretary of the Institution shall be appointed by the Council, and they shall determine the terms and conditions of his appointment. The provisions of Sections 177 and 179 of the Act shall apply and be observed.

It shall be the duty of the Secretary, in person or by deputy, under the direction of the Council, to conduct the correspondence of the Institution; attend all meetings of the Council and Committees thereof; take minutes of the proceedings of such meetings; superintend the publication of such papers as the Council may direct; have charge of the Library; and conduct the collection of all subscriptions. He shall also engage and be responsible for all persons employed under him. He shall conduct the ordinary business of the Institution in accordance with these Articles and the direction of the Council.

Auditors

68. Duly qualified Auditors shall be elected, and their duties shall be regulated in accordance with Sections 159 to 162 of the Act, the members of the Council being treated as Directors mentioned in these Sections.

Officials

69. The Council, as seems expedient to them from time to time, shall determine whether all or any of the Officials of the Institution, other than the Auditors, be engaged for full or part-time employment, and to fix their rate of remuneration, if any.

GENERAL MEETINGS

70. A General Meeting shall be held once in each calendar year, which shall be called the Annual General Meeting and shall be specified as such in the notice convening it. All other General Meetings shall be called Extraordinary General Meetings.

71. The Annual General Meeting shall take place at such place in the United Kingdom and at such time as shall be determined by the Institution in General Meeting or by the Council. The Annual General Meeting shall be held not later than the 31st January immediately following the end of the preceding financial year, nor after a greater interval than fifteen months after the last preceding Annual General Meeting.

72. An Extraordinary General Meeting may be convened at any time by the Council, and shall be convened by them upon such requisition, or, in default, may be convened by such requisitionists as provided in Section 132 of the Act.

73. The quorum for a General Meeting shall be fifteen members, personally present and entitled to vote. In the event of the quorum not being formed within half an hour of the time announced for the commencement of the Meeting, the Meeting, if convened on the requisition of members, shall be dissolved. In any other case, it shall stand adjourned to the same day in the next week at the same time and place, and if at the adjourned Meeting a quorum is not present within half an hour from the time appointed for the Meeting, the members present shall be a quorum.

74. Twenty-one days' notice in writing of every General Meeting (exclusive both of the day on which the notice is given or deemed to be given and of the day fixed for the Meeting), specifying the place, day and hour of the Meeting, and the general nature of any special business to be transacted thereat, shall be given to the Auditors and to every person on the register of members of the Institution except as provided by Article 82, and (subject to Section 140 of the Act), no other special business shall be transacted at such Meeting; but the accidental omission to give such notice to or the non-receipt of such a notice by any person entitled to receive the same, shall not invalidate the proceedings of such Meeting. No notice of the business to be transacted (other than such ballot list as may be requisite in case of elections) shall be required in the absence of special business.

75. Special business shall include all business for transaction at an Extraordinary General Meeting, and all business for transaction at an Annual General Meeting, with the exception of the consideration of the accounts and balance sheets and the ordinary reports of the Council and Auditors, and the fixing of the remuneration of the Auditors.

76. The President, or him failing, a Vice-President, or him failing, the Chairman of the Council, or him failing the Vice-Chairman of the Council, shall preside as Chairman at every General Meeting of the Institution. If none of the Principal Officers is present within fifteen minutes from the time appointed for holding the Meeting and willing to act as Chairman, the members present shall choose someone of their number to act as Chairman.

77. The Chairman may, with the consent of any Meeting at which a quorum is present, and shall if so directed by the Meeting, adjourn the Meeting from time to time and from place to place.

78. No persons other than corporate members shall have the right to vote at any General Meeting of the Institution and each corporate member shall have one vote, but in the case of an equality of votes, the Chairman of the Meeting shall have a second or casting vote. All votes shall be given personally and proxies shall not be allowed.

79. At any General Meeting of the Institution a resolution put to the vote of the Meeting shall be decided on a show of hands unless a poll is demanded by at least two corporate members present and entitled to vote before the declaration of the result of the show of hands. Unless a poll is so demanded, a declaration by the Chairman that a resolution has, on a show of hands of hands, been carried, or carried unanimously, or by a particular majority, or lost, or not carried by a particular majority, and an entry to that effect in the book of proceedings of the Institution, shall be conclusive evidence of the fact, without proof of the number or proportion of the votes recorded in favour of, or against, that resolution. If a poll is duly demanded, it shall be taken at such time and place and in such manner as the Chairman directs and the result of the poll shall be deemed to be the resolution of the Meeting at which the poll was demanded. The result of the poll shall be reported in the official organ of the Institution. No poll may be demanded on the election of a Chairman of a General Meeting, or on a question of adjournment which shall, if necessary, be decided by a show of hands.

NOTICES

80. A notice may be served by the Council or by the Secretary of the Institution upon any member, either personally or by sending it through the post in a prepaid letter which may or may not also contain the official organ, addressed to the member at his address as registered in the books of the Institution.

81. Any notice, if served by post, shall be deemed to have been served on the day following that on which the letter containing the same was put into the post; and in proving such service it shall be sufficient to prove that the letter containing the notice was properly addressed and stamped and put into the Post Office.

82. No member, not having a registered address within the United Kingdom, shall be entitled to any notice; and all proceedings may be had and taken without such notice to the member in the same manner as if he had had due notice.

83. The Journal of the Institution of Production Engineers shall be the Official Organ for the publication of notices including notices of general meetings and other information at the discretion of the Council, and shall be sent to each member as and when published.

PROPERTY AND FUNDS

84. Any donation may be accepted by the Institution.

85. All the monies of the Institution, in excess of such current balance in the hands of the Treasurer, as the Council shall from time to time require the Treasurer to keep in hand to meet the current expenses of the Institution, shall be invested subject to the provisions of the Memorandum of Association.

86. The Council shall endeavour to secure for the Institution the copyright of Papers presented to the Institution and shall make provision to protect the Institution against actions-at-law for infringement of copyright or libel which may arise from the presentation or publication of such Papers by the Institution.

87. Each Councillor shall be accountable in respect of his own acts only, and shall not be accountable for any acts done or authorised to which he shall not have expressly assented. No Councillor shall incur any personal liability in respect of any loss or damage incurred through the act, matter, or thing, done, authorised, or suffered by him, being done in good faith for the benefit of the Institution, if believed by him to be within, although actually in excess of, his legal power; but the provisions of this Article are subject to the provisions of Section 205 of the Act.

ACCOUNTS

88. The Council shall cause proper and sufficient books of account to be kept in accordance with the requirements of Section 147 of the Act with respect to:—

(a) The assets and liabilities of the Institution.

(b) The sums of money received and expended by the Institution and the matters in respect of which such receipts and expenditure takes place; and

(c) All sales and purchases of goods by the Institution.

89. The books of account shall be kept at the Registered Office or (subject to Section 147 (3) of the Act), at such other place or places as the Council shall think fit, and shall always be open to the inspection of the members of the Council.

90. The Institution in General Meeting may from time to time impose reasonable restrictions as to the time and manner of the inspection by the members of the accounts and books of the Institution, or any of them, and subject to such restrictions the accounts and books of the Institution shall be open to the inspection of members at all reasonable times during business hours.

91. At each Annual General Meeting the Council shall, in accordance with Sections 148, 150 and 157 of the Act, cause to be prepared and to be laid before the Institution an income and expenditure account and a balance sheet made up to the end of the immediately preceding financial year. Every such balance sheet shall be accompanied by a report of the Council, and a report of the Auditors and a copy of such account, balance sheet and reports, and of all other documents (if any) required by the Act to be annexed or attached thereto or to accompany the same, shall be sent to all persons entitled to receive notices of General Meetings not less than twenty-one clear days before the date of the Meeting, in the manner in which notices are hereinbefore directed to be served. The Auditors' report shall be read before the Meeting, as required by Section 162 of the Act.

DISSOLUTION

92. Clause 9 of the Memorandum of Association of the Institution relating to the Winding Up and Dissolution thereof shall have effect as if the provisions of that Clause were repeated herein.

REPORT ON ELECTION OF MEMBERS TO COUNCIL 1953/54

In accordance with Article of Association No. 33(c) six of the twelve elected Members of Council (five Members, one Associate Member) retired by rotation.

For the six vacancies for elected Members, eight nominations were received. As a result of the ballot conducted in accordance with Article of Association No. 35, the following were elected:—

Mr. H. W. Bowen, O.B.E.
Mr. R. M. Buckle
Mr. W. Core
Professor T. U. Matthew
Mr. A. L. Stuchbery.

For the one vacancy for the elected Associate Member, four nominations were received. The Associate Member elected was:—

Mr. R. S. Clark.

Ballot papers were circulated to 5,035 Corporate Members in the United Kingdom.

Details of the voting issued by the Institution's Auditors are as follows:—

Eligible papers included in the ballot		1,277
Rejected:—		
Incorrect number of votes recorded	20	
Papers not marked in ink	15	
Spoiled papers	10	
Envelopes unsealed	8	
Insufficiently stamped—returned by G.P.O.	11	
Papers received after closing date ...	17	
	—	81
Total number of ballot papers returned		1,358

The full list of Council Members for the current year is published in the Journal.

REPORT OF COUNCIL

1st July, 1952 to 30th June, 1953

TO BE PRESENTED BY THE CHAIRMAN OF COUNCIL AT THE ANNUAL GENERAL MEETING

28th JANUARY, 1954.

THE Annual General Meeting is the occasion when the Council of the Institution formally places before the members an account of the Institution's activities for the year. It is therefore my privilege as the Chairman of Council to present to you a Report of the Institution for the year from July, 1952, to June, 1953.

It has been a year of considerable activity throughout the Institution and some changes of far-reaching importance have been introduced into our Institution life. Not the least of these has been the introduction of the new format of our Journal, to which I will refer later in this Report. The new Journal was one of the changes recommended to your Council by the Special Committee on Organisation, of which I had the honour to be the Chairman, and to which I referred in my Report last year.

Articles of Association

A full and careful consideration of the recommendations contained in the Report of the Special Committee has engaged the attention of your Council throughout the year under review. The result of your Council's deliberations is included in the agenda of business to be transacted today, namely, the motion in the name of the Vice-Chairman of Council, Mr. G. R. Pryor, that the Institution should adopt new Articles of Association. Your Council have decided that it would be in the interests of the Institution to adopt the majority of the proposals of the Special Committee and in arriving at this decision, your Council was in close consultation with all the local Section Committees. In order to give full effect to the changes, it was evident that the Articles of Association would have to be altered and it was thought appropriate, at the same time, to make various other minor amendments in the Articles of Association.

The difficult and complicated task of drafting the new Articles of Association was entrusted to Mr. Pryor, the Vice-Chairman of Council. After a preliminary study, Mr. Pryor recommended to the Finance and General Purposes Committee that it would be preferable to devise entirely new Articles for approval by the members at the Annual General Meeting, rather than to submit a long list of detailed amendments, some of which would be very minor in character and others of major importance.

With the collaboration of the Finance and General Purposes Committee and with the assistance of Headquarters staff and the Institution's legal advisers, Mr. Pryor has succeeded in producing a new set of Articles of Association which have been approved by your Council and which will be submitted to you for adoption later in the Meeting. The proposed new Articles are printed in full on pages 56 to 62 of the January, 1954 Journal.

Qualifications for Membership

The major changes fall into separate groups. The first concerns the qualifications for membership of the Institution. As you are aware, for some years past our standards of entry into the Institution have been progressively raised and the qualifications for membership as set out in the new Articles of Association, numbers 13 to 19, reflect this development of our standards. The most important change is the removal of the arbitrary age limit of 35 for the Associate Membership examination. Under the present rules, candidates for admission to Associate Membership who are under 35 must satisfy the Institution's examination requirements; but the Institution is not empowered to ask for any examination tests of candidates over 35. The most your Council can do is to call upon such candidates to submit a thesis. Under the new proposal, your Council will have the power to ask all candidates, whatever their age, to satisfy the Institution's examination requirements.

Another change is to raise to 40 the minimum age for direct election to full Member, as under the present rules, a rather absurd anomaly exists. The minimum age now for direct election to full Member is 33. Thus between the ages 33 to 35 it would appear to be easier to become a full Member than to become an Associate Member. It may well be that the raising of our standards of admission may cause a slight check in the rate of intake of new members, but I am sure that everyone will agree that these provisions are very wise in the long term interests of the Institution.

The "Regional Plan"

The second major group of changes in the Articles of Association, and one which has probably caused the most discussion, involves the change in the

Institution's constitution. It has always been the policy of the Institution to establish Local Sections wherever there was a sufficient number of members to justify this course. At the moment there are 29 full Sections and 8 Sub-Sections in the United Kingdom and 8 Sections outside the United Kingdom. It is now proposed that the Sections and Sub-Sections in the United Kingdom should be grouped into 12 Regions. The boundaries of these Regions are not defined in the Articles, so as to permit of flexibility without the constant need to change the Articles.

The "Regional Plan", as it has been called, offers a number of important advantages to the Institution. The first of these will be a control on the effective size of your Council. Under the present constitution, the setting up of new Sections automatically increases the size of the Council. Similarly, the growth of existing Sections beyond a certain number of members again increases the size of Council and your Council has grown steadily over the years. For example, in 1930, the total number of members of Council was 33; in 1940 the number had risen to 48; today it is 83 and the growth is continuing. A large and ever-growing Council is unwieldy and is not conducive to good government.

It is now proposed that Council representation should be on a Regional basis and not on a Sectional basis, and the immediate effect will be to reduce the size of your Council to about 48. Another advantage which is offered is that responsibility for the expansion of the Institution will be very largely in the hands of Regional Committees. It will be the responsibility of the Regional Committee to keep a watchful eye on the growth of membership within the Region and to ensure that interest is fostered in appropriate places. At the moment, by far the greatest number of Institution meetings are arranged by Local Sections, almost the only other meetings being those few which are arranged centrally, such as our three named Papers: the Sir Alfred Herbert Paper, the Viscount Nuffield Paper and the George Bray Memorial Lecture; our National Conference, which is held every two years; and occasional *ad hoc* meetings. It is not practicable for the Institution to promote too many meetings of a national character because of the problems of time and travel which they involve. With the Regional System, it will be possible for regional meetings of considerable importance to be held and it will be possible for members to attend these meetings with the minimum loss of time and inconvenience of travel. There have been a sufficient number of *ad hoc* meetings of this kind in the past to demonstrate their value. In the Midlands, for example, during the past few years a number of such meetings has been held and have attracted large audiences of members from the Midlands region. A more recent example was the Conference on the Problems of Aircraft Production, which the Southern Section organised at Southampton University in December, 1952. Although this Conference was organised by the Southern Section Committee, it attracted members from all the neighbouring sections and even from so far afield as Northern Ireland.

Local Finance

You will have observed also from a study of the new Articles, that it is proposed to put a limited amount of direct financial control into the hands of Regional Committees. In the past, it has not been found possible to place financial control in the hands of Local Sections for a variety of reasons, the principal one being the disparity in the size of Local Sections. It has been found from experience that it costs almost as much to run a Section of 50 members as it does for one of 250 members, so that any system of capitation allowance was highly unsatisfactory. With the much higher aggregation of members in the Region it will be quite practicable to make direct grants to Regions based on the number of members, and it will be the responsibility of the Regional Committee to see that each Section within the Region has an adequate share of funds in accordance with its needs.

One point upon which doubts have been expressed is that Local Sections will no longer have a direct representative on the Council; they will have to convey their views to Council through their Regional representative. On the other hand, however, the direct liaison between Local Sections and the Headquarters of the Institution will be maintained as hitherto. Furthermore, Local Sections will continue to deal with applications for membership on the same basis as before.

Standing Committees

Your Standing Committees, who are responsible for the administration of the Institution under the direction of Council, have had a busy year. I will deal with each in turn and I will begin with the Finance and General Purposes Committee, which is the principal policy-making Committee :—

Finance and General Purposes

The Committee has naturally been much engaged with the work of reshaping the Articles of Association, to which I have referred above. Each of the other Standing Committees is represented on the Finance and General Purposes Committee, so that it can be said that this Committee represents all sections of the Institution's many activities. Their most important task, of course, is the control of the Institution's finances. All members have had an opportunity of studying the Balance Sheet and Statement of Income and Expenditure published in the January, 1954 Journal. In accordance with the requirements of the Companies Act, the accounts of our Sub-Councils in Australia and South Africa and our Sections in Bombay, Calcutta and New Zealand, have been amalgamated with the U.K. accounts. Except for Local Section expenses, our expenditure during the year was very much what we had planned it to be. For the past two or three years, we have

budgeted for, and have achieved, surpluses of income over expenditure of the order of £2,000, but on referring to the Appropriation Account you will see that this year our surplus is reduced to £1,135, although we budgeted again for a surplus of approximately £2,000. The principal reason for this fall in our surplus of income over expenditure is the very much increased activity of our Local Sections in the United Kingdom. During the year, Head Office services on behalf of Local Sections, in the form of printing, duplicating and circulation of lecture tickets and similar items, was double the amount spent in the previous year, and accounts very largely for our failure to achieve our budgeted surplus. It is the view of your Finance and General Purposes Committee that some of this expenditure may be extravagant. Proposals have been submitted to Local Sections which through better planning, will show an economy in Section expenses without in any way restricting their activities. Another unexpected item of expenditure was the payment of local rates, an item which appears for the first time in our accounts. The rating authorities have decided that the Institution is no longer entitled to enjoy the privilege of exemption from rates under the Scientific Societies Act.

It is the opinion of the Finance and General Purposes Committee that it is highly desirable that the Institution should achieve annual surpluses of the order of £2,000 a year to maintain an adequate financial position.

Dealing with our income, you will observe an item which appears for the first time, namely, recovery of income tax on covenanted subscriptions amounting to £464. Although this amount is, strictly speaking, income, your Council have decided that it should be transferred to a special account and be used for financing special activities and not be used for normal routine expenditure. You will see that the transfer has been made in the Appropriation Account.

The income for the Journal shows a substantial increase as a result of the introduction of the new form of the Journal. The year under review includes six months of the old Journal and six months of the new. The expenditure, of course, is correspondingly increased because of the larger size and you will notice that there was a net loss on the Journal Account of about £200. The budgeted loss was £350, so the Editorial Committee are to be congratulated upon so successful launching the new Journal and keeping within the budget. It is our intention that the Journal should pay its way and in the current year, without anticipating figures, I can say that there is every promise that this position will be achieved.

Turning to the Balance Sheet, you may feel—as your Council does—that our current assets are not really adequate when set against the current liabilities, and your Council is most anxious that this position should be improved. The overseas Sections, as usual, have contributed to our central funds, but it must be remembered that some of our current assets, in fact between £2,000—£3,000, are outside the United Kingdom and are not therefore immediately available for current use in the United Kingdom.

The same remarks apply to our cash position at the end of the year and I set out below an analysis of our various banking accounts to make the position clear. It will be seen again that a considerable proportion of our cash balances are outside the United Kingdom.

Bank Balances and Deposits at 30th June, 1953

	In Hand		*Overdrawn*
U.K. Main Account			£3,610
U.K. Main Account—Deposit on new Headquarters ...			£3,500
Section Account (Head Office)	£168		
„ „ (Cash in Hand)	81		
Petty Cash Account (Head Office)	46		
Other U.K. Accounts ...	188		
Sub-total A	£483		
Overseas Accounts			
Australia	1,369		
South Africa	727		
India:			
Bombay	75		
Calcutta	628		
New Zealand	308		
Sub-total B	£3,107		
Total in hand A + B =	£3,590	Total Overdrawn	£7,110
		Less in hand ...	3,590
Bank overdraft as per Balance Sheet =			£3,520

It should be remembered of course that the overdraft on the Main Account is a very temporary affair and is held for only a matter of weeks. During the month of June which is at the very end of the financial year, the Institution's cash position generally weakens but of course on the 1st July with the new subscriptions there is a flood of cash into the Institution's main banking account which immediately restores the position.

The importance of exercising the greatest care in the utilisation of our financial resources is underlined by the necessity to acquire new Headquarters for the Institution. Full details about the new Headquarters have been published elsewhere and suffice it to say for the moment that the response to the Building Fund Appeal issued by Sir Cecil Weir has been encouraging and will be of the greatest assistance to the Institution in meeting its obligations.

Editorial and Papers Committees

The formation of the Editorial Committee and the Papers Committee to take the place of the previous Technical and Publications Committee was one of the proposals of the Special Committee on Organisation which has been implemented this year, and these two Committees took up office on the 1st July, 1952. Their work has already borne fruit. Publication of the Journal in its new form began in January, 1953, and has proved to be a highly successful development.

The new Journal has brought many congratulatory messages to the Editorial Committee and has considerably enhanced the prestige and professional standing of the Institution. At the same time, some helpful criticisms have also been received, of which the Editorial Committee have taken note.

Mr. M. Seaman was Chairman of the Editorial Committee throughout the year and he has been re-elected for a further year of office. The main concern of the Papers Committee has been the establishment of the "Named" Papers, and also to build up the pool of papers for the Editorial Committee. As it happened, neither of the Named Papers was presented during the year. It had been hoped, as I forecast last year, that General Appleyard, a Past-President of the Institution, would inaugurate the Viscount Nuffield Paper, but a prolonged spell of overseas travel made it impossible for him to do this and the projected meeting was cancelled. Plans were made, however, for the presentation of these Papers during the following year, and three named Papers have been presented since the close of the year under review. Although a review of these meetings should probably be included in the Report at next year's Annual General Meeting, I will just refer briefly to them :

The *Sir Alfred Herbert Paper* was presented by Sir John Cockcroft, Head of the Atomic Research Establishment at Harwell, at the Sheldonian Theatre, Oxford, in July, 1953. Sir John Cockcroft took as his subject "Industrial Application of Radio-Active Materials" and the meeting was attended by about 700 members and visitors. The *George Bray Memorial Lecture* was inaugurated at Leeds University on November 9th. Sir Harry Pilkington, Chairman of Pilkington Bros. Ltd., and President of the Federation of British Industries, presented the Lecture, his subject being "The Manufacture of Plate Glass". The *Viscount Nuffield Paper* was inaugurated on December 16th at the Royal Institution in London when the lecture was presented by The Rt. Hon Lord Sempill, A.F.C., a Past-President of the Institution, who spoke on "Productivity—Are We On The Right Road?"

In establishing these lectures, the Papers Committee have brought to fruition a project which was initiated some years ago by the old Technical and Publications Committee. In addition to this important work in connection with the Named Papers, the Papers Committee also had an enormous amount of routine work during the year in the reading and assessing of the many papers that are presented at Section Meetings. They have kept the Editorial Committee well supplied with material for the Journal. Mr. W. J. T. Dimmock was Chairman during the year and he has been re-elected for a further year of office.

Research

The Research Committee continued its policy of determining what particular branches of industrial activity should be the subject of investigation and then appointing sub-committees to carry out the research. In collaboration with the Joint Committee on the Measurement of Productivity, on which the Institution is joined by the Institute of Cost and Works Accountants, two new sub-committees were set up. One sub-committee has been asked to investigate and report on Production Control, under the Chairmanship of Mr. F. G. S. English; the other sub-committee has been asked to undertake an investigation of Works Statistics under the Chairmanship of Mr. Sutton, a member of the Institute of Costs and Works Accountants. It is hoped that reports of their findings will be published during the coming year.

The Materials Handling Sub-Committee, under the Chairmanship of Mr. T. W. Elkington, completed their investigations and produced a report which the Institution published under the title of "A Review of Materials Handling in British Industry". The review is in the nature of a general survey, but later when more resources are available, it is hoped to extend the survey so as to be able to issue detailed reports of investigations in particular industries. The Materials Handling Sub-Committee collaborated with the British Productivity Council in the production in January, 1953, of a booklet on Materials Handling Case Studies, published under the title: "As the Spirit Moves". The Research Committee have also formed a new Sub-Committee to investigate Materials Utilisation in Industry in the United Kingdom. Mr. R. M. Evans has been elected Chairman of this Sub-Committee.

The Institution was invited to nominate a representative to serve on the Committee dealing with the British contribution to the 10th International Management Congress to be held in Brazil in 1954. Mr. John Loxham has accepted the Research Committee's invitation to be the Institution's representative.

Sir Lionel Kearns was Chairman of the Research Committee during the year. He has now been succeeded by Mr. B. H. Dyson; Mr. F. G. S. English has been elected Deputy Chairman.

Hazleton Memorial Library

The Hazleton Memorial Library, under the direction of the Library Committee, has continued to grow steadily during the year. The new shelving which was erected in the first part of 1952 is already full to capacity, in spite of the Library Committee's determination to keep the collection "pruned" and to discard obsolete or superseded material. There has been a steady increase in the use of the Library by members and also in the number of enquiries received from other libraries and associations. One very serious handicap in the promotion of the use of the Library by members, is the lack of a published catalogue of the collection, so that it is difficult to convey to members an appreciation of the resources at their disposal. The production of a catalogue is very expensive, but it is so important a part of the library service that it has been decided to publish the catalogue during the coming year and work is now proceeding with that object in mind. During last winter the experiment was tried of opening the Library every Saturday morning, but the number of

members who made use of this facility was so small that the Library Committee did not feel justified in continuing this service.

With the changeover from the Technical and Publications Committee to the Papers Committee and the Editorial Committee, the Library Committee assumed responsibility for the abstraction and reviewing of new books. The Library Committee have had considerable assistance in this task from members of local sections and they are most grateful for the help which they have received. Several cases have arisen when books have been reviewed adversely and the Library Committee have urged on the Editorial Committee the importance of publishing such reviews in the interests of members.

The Library Committee is responsible for establishing Library policy and the general maintenance of the library. A Sub-Committee, known as the Books Selection Committee, has been set up with specific responsibility for the selection of books, journals, catalogues and other material to be included in the library. Lord Sempill was Chairman of the main Committee during the year and has been re-elected for a further year of office. Mr. J. C. Z. Martin has been elected Vice-Chairman of the main Committee and Chairman of the Books Selection Sub-Committee.

Standardisation

The Standards Committee have continued their work in close collaboration with the British Standards Institution. The British Standards Institution have expressed their appreciation of the valuable services rendered by members of our Institution. A great number of draft British Standards Specifications have been received during the course of the year and the comments and recommendations of the Standards Committee have been passed to the British Standards Institution. Our Institution is at present represented by 146 members serving on 113 British Standards Institution technical committees. The Standing Committee have prepared a list of British Standards which have general application, copies of which have been circulated to technical colleges so that they can be brought prominently to the notice of students. Mr. S. G. Nash has been appointed as the Institution's representative on the Joint Committee on Materials and their Testing. Mr. C. M. Holloway was Chairman of the Committee during the year and he has been re-elected for a further year. Mr. K. J. Hume has been elected Vice-Chairman.

Awards

On the recommendation of the Awards Sub-Committee, the following awards were made during the year:—

Institution Medal for the Best Paper presented by a Non-Member.

To Dr. J. D. Jevons, B.Sc., F.R.I.C., for his Paper "How the Production Engineer can be helped by the Metallurgist".

Institution Medal for the Best Paper presented by a Member.

To Mr. A. Cameron, A.M.I.Prod.E., for his Paper "Increased Productivity by Workshop Practice".

Hutchinson Memorial Award for the Best Paper presented by a Graduate

To Mr. J. E. Poulter, for his Paper "Industrial Application of Porous Ceramics".

Institution Prize for Best Performance in the Higher National Certificate in Production Engineering

To Mr. W. E. Simpson, Grad.I.Prod.E.

Lord Austin Prize

Awarded to Mr. V. C. Jones, Graduate, for his essay on "The Pressure Die Casting Process (with special reference to Light Alloy Casting)".

Schofield Travel Scholarships

No award was made.

The Awards Sub-Committee were unable to recommend the award of any Schofield Travel Scholarship during the year. The number of entries was much smaller than hitherto and the standard of entrant was not high enough to justify the award of any scholarship. The Awards Sub-Committee were disappointed at the low number of entrants for this very valuable award. Energetic steps have been taken to bring it to the notice of Graduate members, with the result that it is gratifying to report a greatly increased number of entries for the coming year. Mr. B. H. Dyson was Chairman of the Awards Sub-Committee during the year and has been re-elected for a further year of office.

Membership

The Membership Committee had a busy year dealing with a large number of applications for membership. It is gratifying to notice that the Institution's membership is steadily growing, although the rate of growth has fallen, due no doubt to the introduction of the Associate Membership examination. The membership on the 30th June, 1953, was as follows:—

	1953	1952
Honorary Members	8	8
Members	1,484	1,475
Associate Members	4,551	4,274
Intermediate Associate Members (this grade ceased to exist on 1st July, 1953)	76	288
Associate	157	158
Graduates	2,006	1,978
Students	963	804
Affiliated Firms	198	201
Total Membership 30th June, 1953	9,443	9,186
Net increase	257	

The Membership Committee, in collaboration with the Education Commitee, gave considerable attention to the qualifications for membership of the Institution and their recommendations have been included in the new Articles of Association to which I have already referred.

The Chairman of the Membership Committee was able to meet a number of Section Committees during the year to discuss matters of membership policy

with them, and these meetings have been most helpful in promoting closer working between Section Committees and the Membership Committee.

Mr. R. L. Paice was Chairman during the year. He has been succeeded by Mr. S. A. J. Parsons.

Education

In previous years, one of the tasks of the Education Committee was the assessment of applications for junior membership. One of the recommendations of the Special Committee on Organisation was that all applications for membership should be dealt with by the Membership Committee, and so the Education Committee have been relieved of this task during the year. Their attention is now entirely devoted to the development of education policy and the direction, through the Joint Examination Board, of the Institution's examination and the operation of the exemptions list.

The Summer School this year was held at Ashorne Hill, near Leamington Spa, which proved to be an ideal venue for this particular activity. It is conveniently situated for travel and, in addition to excellent lecture room facilities and rooms for discussion, there are ample amenities for those attending the School. Approximately 100 members and visitors attended the Summer School, the theme of which was "The Processes of Production". The Summer School is now well established and has become a permanent part of the Institution's programme.

The Committee were very sorry to lose, during the year, the services of Mr. T. B. Worth, the Education Officer, and Mr. G. E. Knight, Assistant Secretary (Education and Membership). Mr. Worth returned to the teaching profession and Mr. Knight was successful in gaining an important post in industry. The Education Committee wishes to record their appreciation of the splendid services which these two officers rendered to the Institution and in particular, to the Education Committee and the Membership Committee, and to wish them every possible success in the future.

"Broadening the Base"

A special sub-committee was set up during the year to examine the proposal to "Broaden the Base" of the Institution, with special reference to membership and education policy involved. This sub-committee, under the Chairmanship of Mr. B. G. L. Jackman, submitted a comprehensive report which was studied jointly by the Education and Membership Committees and has now been referred to Section Committees for study.

The Education Committee recommended to the City and Guilds of London Institute that a section on Inspection should be added to the Machine Shop Engineering examination of the C. & G.L.I. and this recommendation was adopted.

During the year education discussion groups were established in London and Birmingham. The object of these groups is to provide facilities for members specifically interested in education, to meet and hold discussions. Mr. J. France was Chairman of the Education Committee last year. Principal C. L. Old has been elected to succeed him.

Local Section Activities

Local Sections have gone from strength to strength, both in the way of membership and local activities. During the year, 330 Lecture Meetings have been held in the United Kingdom and 50 have been held in the Sections overseas. Many Sections have held successful Dinners and Dances and other social functions, and also many interesting works visits and similar activities have taken place.

The Oxford Sub-Section was raised to full Section status less than a year after its inauguration, and the Gloucester Sub-Section is now firmly established. A Sub-Section of the Leicester Section has been established in Peterborough, and a Sub-Section of the Birmingham Section has been established in Worcester. During the year covered by this report arrangements were well advanced to form a Sub-Section of the Sheffield Section in Doncaster.

Two very successful Regional Meetings have been held, the first in the East and West Ridings and the second in the Midland Region.

In November a Productivity Exhibition arranged by the North Eastern Section was held in Newcastle-upon-Tyne. A Conference on "Problems of Aircraft Production" was held in Southampton, and this was organised by the Southern Section Committee.

As usual the Section Hon. Secretaries Conference was held in Birmingham in May. This Conference is a great help in maintaining the very good relations which exist between Section Hon. Secretaries and Head Office permanent staff, and also helps to iron out the various administrative problems which arise over the year.

The activities of the Graduate Sections have been well to the fore. The Annual Graduate Representatives Conference was held this year in Halifax, and was very well attended. The second Graduates and Students one-day National Convention was held in Birmingham, and this proved to be very successful. Both the Halifax Graduate Section and the London Graduate Section have held very successful Week-end Schools.

During the year under review two of the Institution's Principal Officers have had the opportunity of visiting Commonwealth Sections. In September, during a visit to Canada, I took the opportunity of meeting as many of the members there as possible, and also gave an address to a Section meeting. Mr. Puckey visited Australia in March and gave separate addresses to the Adelaide, Melbourne and Sydney Sections.

Members from Great Britain have visited various parts of the Commonwealth and Empire, and at the same time a number of members from Overseas have visited us during the year.

The Institution provided a stand at the International Machine Tool Exhibition which was held at Olympia in September. In addition to the facilities provided for members, the stand also helped in some small way to publicise the Institution's work.

National Conference

A National Conference was held in Harrogate in the summer and although the attendance was smaller

than at previous Conferences, it proved in every way to be one of the best Conferences which have yet been organised by the Institution. The addresses given at the Plenary Sessions were very good, and the discussion groups were of a very high order.

Council Meetings

Your Council has met four times during the year. A change in the order of business has been introduced so that, under the new arrangement, all routine business is dealt with in the morning session and the afternoon session is devoted to a discussion of some particular point of Institution policy. During the year under review most of the policy discussions have been devoted to the proposals of the Special Committee on Organisation and to the new Articles of Association, upon which I have already commented.

One special meeting of the Council was held during the year which was attended by Sir Ewart Smith and Sir Thomas Hutton, representing the British Productivity Council. These two gentlemen outlined the proposed programme of the British Productivity Council, which was fully discussed by the Institution's Council, who gave an assurance to the British Productivity Council of the Institution's willing support and co-operation in their endeavours.

Services of Members

I should like once more to record the Council's appreciation of the enormous services rendered to the Institution during the course of the year by many members. It is of the very essence of professional life that individual members should contribute to the profession's growth and development. The steady growth and expansion of our Institution is an adequate tribute to the way in which our members accept their responsibiliites.

Headquarters Staff

During the year, a number of changes have taken place among the Senior Staff of the Institution. We have already referred to the fact that Mr. G. E. Knight left the Institution in order to take an important post in industry, and that Mr. T. B. Worth decided to resign his appointment to return to teaching. In addition, the Institution lost the services of Mr. N. R. Tribble, who accepted a more important appointment in industry in order to widen his experience, and at the end of the year, Miss D. Keith, Mr. Woodford's Secretary, left us to get married. The Institution is indebted to them for their untiring efforts during their years of service, and I am sure they will take with them the good wishes of all members for their future careers.

Nevertheless, the loss of these important people during a year of great activity has thrown an unusually heavy strain on the Headquarters Staff, and the Council are particularly grateful to Mr. Woodford and the remainder of the staff for their energetic efforts and for the manner in which they covered the vacant posts so that the work of the Institution could proceed at the very high standard which has been reached.

Quite recently new appointments have been made, to which some reference will be made in another place. We are hoping that some re-arrangement of the Terms of Reference of the Senior Staff concerned will provide a fresh invigoration for the work which lies ahead.

We welcome Mr. H. W. Badger and Mr. N. J. Day to our Organisation, and wish to assure them that we shall do all in our power to assist them in their endeavours.

Honours

It is recorded with very great pleasure that the following members have been honoured by the Sovereign during the year :—

W. J. Mason, C.B.E.
L. A. Jouning, M.B.E.
H. Moliver, M.B.E.

Obituary

It is with regret that the deaths of 38 members during the year must be recorded. Their names have been published in the Journal.

The President

During my first year as Chairman of Council I had the great privilege of serving under the Presidency of Sir Cecil Weir. Sir Cecil Weir has had a profound influence upon the direction of Institution affairs. His great experience of public life and his exceptional administrative ability have been of great benefit to the Institution. Almost within a few weeks of taking office, he was invited by the Foreign Secretary to go to Luxembourg as Head of the U.K. Delegation to the European Coal and Steel Community. This meant that Sir Cecil had to take up residence in Luxembourg, and your Council records with special appreciation the way in which Sir Cecil continued to discharge all his duties as President of the Institution, although this meant a great amount of personal inconvenience and extensive travelling. Sir Cecil Weir found it necessary at the end of one year of office to resign from the Presidency and did not offer himself for re-election for a second year of office, which has been the practice in the Institution for very many years. Your Council had no alternative but to accept Sir Cecil's resignation with the most profound regret, but at the same time, with a deep sense of obligation.

The Institution has indeed been fortunate in having as its Presidents not only men of great distinction but men who were willing to work hard for the Institution and further its progress. Sir Cecil Weir has brought added distinction and dignity to the office of President of the Institution.

Mr. Walter Puckey was elected President to succeed Sir Cecil Weir. Mr. Puckey's work for the Institution is so well known that it is not necessary for me to detail it here. In electing Mr. Puckey as President, your Council feel that they are doing honour to one who has given so freely of his services to the Institution for many years. I can do no better in closing this Report than to say that your Council is looking forward to a period of further expansion of the Institution and an extension of its influence in public affairs, under the vigorous and informed leadership of Mr. Puckey.

THE INSTITUTION OF PRODUCTION ENGINEERS

BALANCE SHEET as at 30th JUNE, 1953

1952	1952		£	£
		Accumulated Funds and Surplus		
25,027		The Viscount Nuffield Gift ...	25,027	
100		The Lord Austin Prize Fund ...	500	
100		The Hutchinson Memorial Fund	100	
500		The George Bray Memorial Fund	500	
2,000		New Building Fund	2,105	
	27,727			28,232
1,780		Leasehold Premises Sinking Fund	1,908	
1,100		Dilapidations Reserve Fund ...	1,200	
	2,880			3,108
	—	Special Reserve		464
	864	Life Subscriptions: *less* amount transferred to Income and Expenditure Account ...		921
	9,399	Income and Expenditure Account		10,070
	40,870			42,795
	5	Hazleton Memorial Library ...		—
	51	Melbourne Prize Account ...		52
	387	Schofield Scholarship		305
		Current Liabilities		
3,076		Sundry Creditors	5,983	
331		Subscriptions received in advance	347	
2,325		Bank Overdraft: *less* Sections and Cash Balances	3,520	
	5,732			9,850
	£47,045			£53,002

1952	1952		£	£
		Fixed Assets		
—		Freehold Premises: deposit paid		3,500
3,481		Leasehold Premises at Cost (Depreciation is provided by a Sinking Fund)		3,481
		Furniture, Fittings and Plant at the net amount standing in the Institution's books at 30th June, 1948	1,531	
		Additions	4,293	
			5,824	
4,112		*Less* Depreciation to date ...	1,836	3,988
27,727		Fund Investments at cost: as scheduled ... ... (Market value £24,099)		28,232
2,880		Sinking Fund Policies: as scheduled (Premiums paid) ...		3,108
	38,200			42,309
		Current Assets		
5,884		Sundry Debtors, Deposits and Stocks	7,856	
1,134		General Investments at cost: as scheduled ... ... (Market value £890)	1,135	
1,650		United Building Society—Deposit (South Africa)	1,650	
		Cash at Bank—		
177		Melbourne Prize Account ...	52	10,693
	8,845			
	£47,045			£53,002

WALTER PUCKEY, *President.*

H. BURKE,
Chairman of Council and Finance Committee.

W. F. S. WOODFORD, *Secretary.*

Report of the Auditors to the Members of The Institution of Production Engineers.

We have obtained all the information and explanations which to the best of our knowledge and belief were necessary for the purposes of our audit. In our opinion proper books of account have been kept by the Institution so far as appears from our examination of those books. Audited Balance Sheets and Accounts have been received from each of the Overseas Sub-Councils and these have been incorporated in the above Balance Sheet and annexed Income and Expenditure Account. We have examined the above Balance Sheet and annexed Income and Expenditure Account which are in agreement with the books of account audited by us and the audited Sub-Councils Accounts supplied to us. No provision has been made for reductions in value of invested funds. In our opinion and to the best of our information and according to the explanations given us the said Accounts give the information required by the Companies Act, 1948, in the manner so required and the Balance Sheet gives a true and fair view of the state of the Institution's affairs as at 30th June, 1953, and the Income and Expenditure Account gives a true and fair view of the excess of income over expenditure for the year ended on that date.

20, Bloomsbury Square,
London, W.C.1.

3rd December, 1953.

GIBSON, APPLEBY AND CO.,
Auditors,
Chartered Accountants.

INCOME and EXPENDITURE ACCOUNT for the year ended 30th JUNE, 1953.

1952	1952		£	£
		To **Establishment Charges**		
241		Rent and Rates	699	
1,049		Light, Heat and Cleaning	1,118	
357	1,647	Repairs and Renewals ...	453	2,270
		,, **Administration Expenses**		
1,894		Postage and Telephone ...	1,394	
3,522		Printing and Stationery ...	3,959	
81		Professional Charges and Insurance	262	
300		Audit Fee	200	
2,353		Travel, Entertaining and Meetings (other than Sections)	2,381	
208	8,358	Miscellaneous	213	8,409
	15,304	,, **Salaries**		16,022
		,, **Section Expenses**		
1,893		United Kingdom	2,078	
2,053		Overseas (Audit Fees £111)	2,225	
911	4,857	Central Services	2,117	6,420
		,, **Journal**		
10,639		Printing	16,735	
1,750		Postage and Envelopes ...	1,977	
700		Institution Papers ...	—	
400	13,489	Reporting	507	19,219
	—	,, **Hazleton Memorial Library**		327
	138	,, **Donations and Grants** ...		245
		,, **Miscellaneous**		
45		Annual Dinner, 1951 ...	—	
112		Exhibition Expenses ...	231	
145		Presidential Regalia ...	—	
44	346	Summer School	95	326
		,, **Provisions**		
476		Depreciation — Furniture and Fittings	542	
100		Dilapidations Reserve ...	100	
127		Leasehold Sinking Fund ...	127	
500	1,203	Schofield Scholarships ...	—	769
	2,030	,, **Balance**—Excess of Income over Expenditure carried down		1,135
	£47,372			£55,142

1952	1952		£	£
		By **Subscriptions**		
27,987		Renewals and Arrears ...	28,516	
281		Transfers	388	
1,496		New	1,543	
3,747		Overseas	3,730	
885		Entrance Fees	887	
—	34,396	Recovery of Income Tax on Subscriptions ...	464	35,528
	1,023	,, **Interest**		1,075
	11,768	,, **Journal Receipts**		18,373
	185	,, **Sale of Publications** ...		91
	—	,, **Surplus on Annual Dinner, 1952**		75
	£47,372			£55,142

APPROPRIATION ACCOUNT

1952		£	£
—	To Transfer to Special Reserve (Tax recovered on subscriptions)		464
9,399	,, Balance carried forward ...		10,070
£9,399			£10,534

1952		£	£
7,369	By Balance at 1st July, 1952 ...		9,399
2,030	,, Excess of Income over Expenditure brought down ...		1,135
£9,399			£10,534

INVESTMENTS 30th JUNE, 1953.

	£ s. d.	£ s. d.
SCHEDULE OF FUND INVESTMENTS		
The Viscount Nuffield Gift		
£7,124 19s. 10d. 3½ per cent. War Stock	7,428 19 8	
£8,554 9s. 0d. 3½ per cent. Treasury Stock, 1977/80	8,598 4 2	
£9,038 0s. 0d. 4 per cent. Canadian Pacific Railway Perpetual Consolidated Debenture Stock	9,000 0 0	
		25,027 3 10
The Lord Austin Prize Fund		
£ 95 8s. 5d. 3½ per cent. War Stock	100 0 0	
£439 8s. 3d. London County 3 per cent. Consolidated Stock, 1920	300 0 0	
Cash at Bank: awaiting investment	100 0 0	
		500 0 0
The Hutchinson Memorial Fund		
£95 8s. 5d. 3½ per cent. War Stock		100 0 0
The George Bray Memorial Fund		
£775 0s. 9d. London County 3 per cent. Consolidated Stock, 1920		500 0 0
New Building Fund		
£2,102 1s. 6d. 3 per cent. Savings Bonds, 1955/65	2,000 0 0	
Cash at Bank: awaiting investment	105 0 0	
		2,105 0 0
		£28,232 3 10
SCHEDULE OF SINKING FUND POLICIES		
Leasehold Premises Sinking Fund		
Norwich Union Life Insurance Society Policy—Premium Paid ...		1,907 10 0
Dilapidations Reserve Fund		
General Accident Fire and Life Assurance Corporation Limited Policy—Premium Paid		1,200 0 0
		£3,107 10 0
SCHEDULE OF GENERAL INVESTMENTS (Unallocated)		
£936 2s. 4d. 3½ per cent. War Stock		982 10 0
£151 4s. 6d. 3½ per cent. Treasury Stock		152 0 1
		£1,134 10 1

The Council of the Institution

1953/54

President
Walter C. Puckey

Chairman of Council
H. Burke

Vice-Chairman of Council
G. R. Pryor

Past Presidents
Major-General K. C. Appleyard, C.B.E., The Rt. Hon. Viscount Nuffield, G.B.E., J. D. Scaife, Dr. H. Schofield, C.B.E.

Vice-Presidents
T. Fraser, C.B.E., E. W. Hancock, M.B.E., J. E. Hill.

Sub-Council Presidents
Australian Sub-Council—J. N. Kirby.
South African Sub-Council—W. G. Gillespie

Section Presidents

J. H. Law .... *Adelaide*
B. G. L. Jackman ...... *Birmingham*
E. H. Y. Burden .... *Bombay*
J. Warren-Boulton .... *Calcutta*
C. J. Luby .... *Canada*
Capt. F. W. Spencer .... *Cornwall*
S. J. Harley .... *Coventry*
A. F. Kelley .... *Derby*
J. Butler .... *Dundee*
E. N. Farrar .... *E. Counties*
Dr. A. F. Muir .... *Edinburgh*
W. P. Kirkwood .... *Glasgow*
J. Blakiston .... *Halifax*
S. Radcliffe .... *Leicester*
E. Burgess .... *Lincoln*
J. O. Knowles .... *Liverpool*
R. E. Leakey .... *London*
W. E. Park .... *Luton*
H. Spencer Smith .... *Manchester*
H. G. Sutton .... *Melbourne*
J. A. Holmes .... *New Zealand*
J. Henderson .... *North Eastern*
J. Ringland .... *N. Ireland*
E. Barrs .... *Nottingham*
L. P. Coombes .... *Oxford*
H. Kirkman .... *Preston*
F. V. Waller .... *Reading*
J. H. Hartley .... *Sheffield*
H. Bainbridge .... *Shrewsbury*
W. G. Gillespie .... *South Africa*
F. C. Cooke .... *Southern*
C. L. King .... *S. Wales*
J. E. Strick .... *Sydney*
E. F. Gilberthorpe .... *Western*
Capt. Leighton Davies, C.B.E. .... *W. Wales*
R. Beasley .... *Wolverhampton*
S. G. Haithwaite .... *Yorkshire*

Additional Section Representatives

E. Percy Edwards ...... *Birmingham*
H. W. Harper, M.B.E. ... *Birmingham*
C. J. Swain .... *Coventry*
H. Gardner .... *Glasgow*
A. P. Peat .... *Leicester*
R. Kirchner .... *London*
F. G. S. English .... *London*
R. K. Allan .... *Luton*
R. H. S. Turner .... *Manchester*
H. G. Gregory .... *Manchester*
T. McCulloch .... *N. Eastern*
E. G. Eaton .... *Preston*
E. Levesley .... *Sheffield*
R. S. Brown .... *Western*
G. W. Wright .... *Western*
C. L. Old .... *Wolverhampton*
H. Tomlinson .... *Wolverhampton*
F. T. Nurrish, M.B.E. ...... *Yorkshire*

Chairmen of Standing Committees
W. J. T. Dimmock B. H. Dyson C. M. Holloway C. L. Old S. A. J. Parsons M. Seaman
The Rt. Hon. Lord Sempill, A.F.C.

Elected Members
A. J. Aiers H. W. Bowen, O.B.E. R. M. Buckle J. E. Burnett R. S. Clark W. Core B. H. Dyson
P. G. Garside B. G. L. Jackman Prof. T. U. Matthew A. L. Stuchbery H. J. Swift, O.B.E.

Overseas Sub-Councils

AUSTRALIA

President
J. N. Kirby

Chairman
J. H. Law

Vice-Chairman
H. G. Sutton

Elected Members
R. W. Deutsher S. Downie N. Eaton N. Esserman W. M. B. Fowler W. Gwinnett W. L. Hemer E. Herbert
J. O. Ogden C. Pullen B. G. Ross J. E. Strick A. Welsh L. W. Worthington

SOUTH AFRICA

President
W. G. Gillespie

Vice-President
H. J. G. Goyns

Past Presidents
B. Anderson R. H. Arbuckle L. H. L. Badham G. Godfrey J. Henry D. Lion-Cachet J. Renwick A. C. Wotherspoon

Elected Members
G. T. Chawner D. N. S. Clare V. J. S. Donnelly C. O. Doehring E. Hamm A. P. R. Hodge D. A. Petrie
G. M. Pratley P. L. Ward H. H. Waters

SUB-SECTION CHAIRMEN

.... *Doncaster*
L. E. Broome .... *Gloucester*
G. A. Daniell .... *Norwich*
A. P. Peat .... *Peterborough*
J. J. Gleeson .... *Rochester*
R. R. Kenderdine .... *South Essex*
H. Porter .... *Stoke-on-Trent*
B. G. L. Jackman .... *Worcester*

Secretary of the Institution
W. F. S. Woodford

SECTION HONORARY SECRETARIES

AUSTRALIA

Adelaide (South Australia) ...	W. L. Hemer, 6 Bedford Street, Brooklyn Park, South Australia.
Melbourne (Victoria Australia) ...	R. W. Deutsher, Bank House, 11 Bank Place, Melbourne, C.I., Victoria, Australia.
Sydney (N. S. Wales)	A. Welsh, Room 802, 16 Barrack Street, Sydney, Australia

CANADA

Canada	T. H. Beard, 144 Glendale Avenue, North York, Toronto.

INDIA

Bombay	Mrs. S. G. Barbet (Acting), Top Flat, 25 1st Pasta Lane, Colaba, Bombay, 5.
Calcutta	N. N. Sen Gupta, 110 Surrendra Nath, Banerjee Road, Calcutta 13.

NEW ZEALAND

New Zealand	H. R. Holmes, Pah Road, Papatoetoe, Auckland.

SOUTH AFRICA

South Africa	The Secretaries, Institution of Production Engineers, Barclays Bank Buildings, Corner Commissioner and Harrison Streets, Johannesburg.

UNITED KINGDOM

Birmingham	B. W. Gould, Dept. of Industrial Administration, College of Technology, Suffolk Street, Birmingham.
Cornwall	F. G. Hawke, 17 Church Road, Pool, Redruth, Cornwall.
Coventry	R. F. Eaton, 232 Longfellow Road, Coventry.
Derby	A. Short, 244 Uttoxeter Road, Mickleover, Derby.
Doncaster Sub-Section	W. H. Edwards-Smith, 32 Westmoreland Street, Balby, Doncaster.
Dundee	K. Fairweather, c/o D. Morrison, 13 Kerrsview Terrace, Dundee, Angus.
Eastern Counties	A. B. Brook, Davey Paxman & Co. Ltd., Britannia Works, Colchester.
Edinburgh	A. Atkinson, Priory House, South Queensferry, West Lothian.
Glasgow	W. H. Marley, G. & J. Weir, Ltd., Coltness Foundries, Newmains Lanarks.
Gloucester & District	P. C. Bradshaw, Dunsworth Cottage, Norton, Glos.
Halifax	Miss N. E. Bottom (Acting), Hopkinsons Ltd., Huddersfield.
Leicester & District	A. T. Vasey (Acting), c/o Wadkin Ltd., Green Lane Works, Leicester.
Lincoln	H. Wright, 101 Longdales Road, Lincoln.
Liverpool	L. C. Jarman, 17 Cambridge Road, Prenton, Birkenhead.
London	R. Hutcheson, Machine Shop Magazine, Dorset House, Stamford St., London, S.E.1.
Luton	J. F. W. Galyer, Engr. Dept., Luton & South Beds College of Further Education, Park Square, Luton.
Manchester	G. R. Parker, 722 Ripponden Road, Moorside, Oldham.
North Eastern	G. D. Robinson, 27 Holme Avenue, Newcastle-on-Tyne 6.
Northern Ireland	W. G. Wyman, "Linden Lea", Cultra, Co. Down, N. Ireland.
Norwich Sub-Section	F. H. S. Heidenstam, 33 Cecil Road, Norwich.
Nottingham	C. N. T. Manfull, Chellaston House, Thurgarton Street, Nottingham.
Oxford	M. J. Inston, 53 Rymers Lane, Cowley, Oxford.
Peterborough Sub-Section	E. G. Perrett, 165 St. Pauls Road, Peterborough.
Preston	F. T. Graham, 254 Whalley New Road, Blackburn, Lancs.
Reading	R. W. H. Mark, "The Beeches", 41 Reading Road, Woodley, Berks.
Rochester & District Sub-Section	W. G. Clements, 101 Featherby Road, Gillingham, Kent.
Sheffield	E. Levesley, The English Steel Corporation Ltd., Sheffield.
Shrewsbury	J. A. Francis, "Meole Meads", Bank Drive, Longden Road, Shrewsbury.
Southern	J. W. Taylor, 44 Deacon Road, Bitterne, Southampton.
S. Essex Sub-Section	P. H. W. Everitt, 6 Hillcrest Road, Loughton, Essex.
South Wales & Mon.	W. D. Porter, 49 Kyle Avenue, Rhiwbina, Cardiff.
Stoke-on-Trent Sub-Section ...	R. Rowley, North Staffordshire Technical College, Stoke-on-Trent.
Western	A. Eustace, 19 Ferndale Road, Northville, Bristol 7.
West Wales	H. P. Sanderson, I.C.I. Ltd. (Metals Division), Waunarlwydd, Nr. Swansea.
Wolverhampton	W. B. Pamment, Wolverhampton and Staffordshire Technical College, Wolverhampton.
Worcester Sub-Section	R. Wheeler, Old Farm House, Parish Hill, Bournheath, near Bromsgrove, Worcs.
Yorkshire	J. L. Townend, 26 Moor Allerton Drive, Street Lane, Leeds 7.

CORRESPONDING MEMBER IN THE MIDDLE EAST

J. Merkine, 45 Arlozoroff Street, Ramat-Gan, Israel.

GRADUATE SECTION HONORARY SECRETARIES

Birmingham	W. Silberbach, 44 Linwood Road, Handsworth, Birmingham 21.
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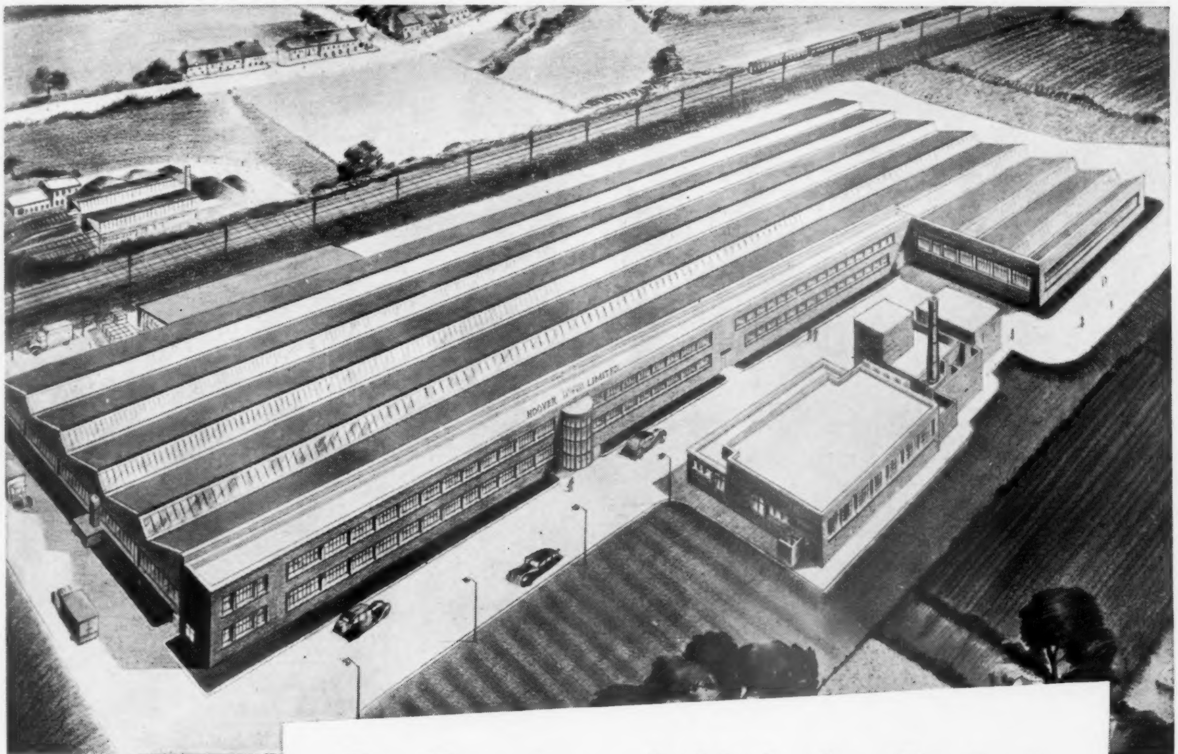

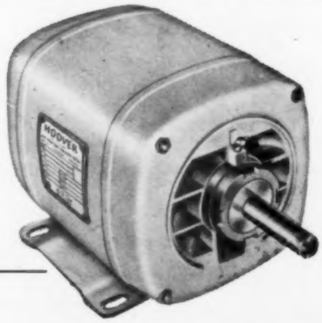

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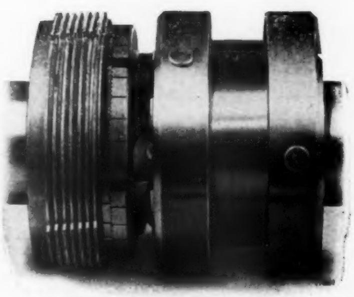

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We shall be glad to submit suggestions for suitable clutches on receipt of the necessary particulars.

We carry a large stock.

Enquiries should be sent to :—
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There's no escaping it– Wrought Iron is safer

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This nick-and-bend test piece clearly shows the fibrous structure of Wrought Iron, which gives it its high durability, shock-resistance and ability to absorb varying stresses and withstand severe vibrations. Wrought Iron is also distinguished by its ductility and exceptionally good machining properties.

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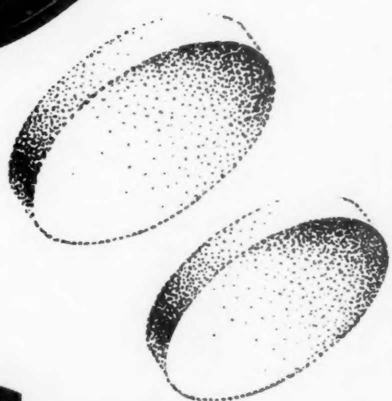

Over Twenty years ago *Mr. Neven introduced his Impregnated Diamond Tools. Great technical advances have been made in succeeding years and production is still under the personal supervision of Mr. Neven. Our latest catalogue gives the widest range of Diamond Tools yet listed for working tungsten carbide, glass, quartz, stone, ceramics and hard refractories, etc.*

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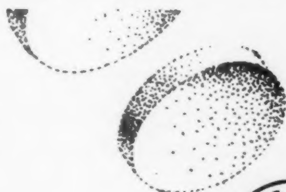

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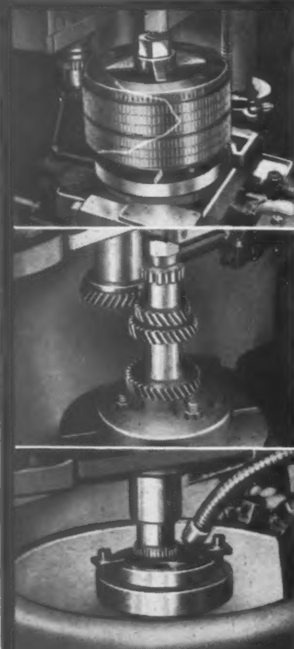
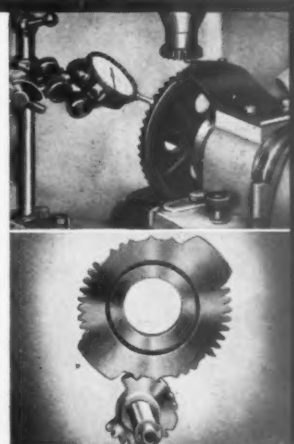
adaptability in gear production



VERTICAL GEAR GENERATING MACHINES **MODEL V10A**

SYKES



External and internal spur and helical gears; splines, serrations and special forms can all be generated at high production rates yet with the greatest accuracy. These machines are automatic in operation and there are no cams to change — rapid set-up is effected by simple adjustment of 2 rollers, reducing idle time to a minimum. Quickly interchangeable rack and contrate gear attachments still further extend the scope of these machines.

V10A max. dia. 14 in. x $2\frac{1}{4}$ in. face and racks up to 36 in. long.

V4 max. dia. $4\frac{1}{8}$ in. x $\frac{7}{8}$ in. face and racks up to 6 in. long.

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Two identical amplifier channels with a maximum gain of 2000 and an upper frequency response of 3 megacycles are features of this new Cossor Double Beam general purpose oscillograph. The repetitive or triggered time base has a sweep duration from 200 milliseconds to 5 microseconds.

The instrument will operate from power supplies of any of the various frequencies and voltages encountered in the Armed Services or from standard civil supply mains. The top and side panels are quickly detachable to allow inspection and a removable plate at the rear of the instrument allows access to tube plates, anode and modulator.

and Voltage Calibrator

MODEL 1433

Primarily designed to be used with the new Cossor oscillograph the Cossor Voltage Calibrator model 1433 provides an accurate means of calibration of input voltages to the plates or amplifiers of any oscillograph. Calibrating voltages are read directly from a wide scale meter without any computation being necessary. Measurements can be made to an accuracy of $\pm$ 3% and the instrument can be used in any application where a source of accurately-known voltage is required.

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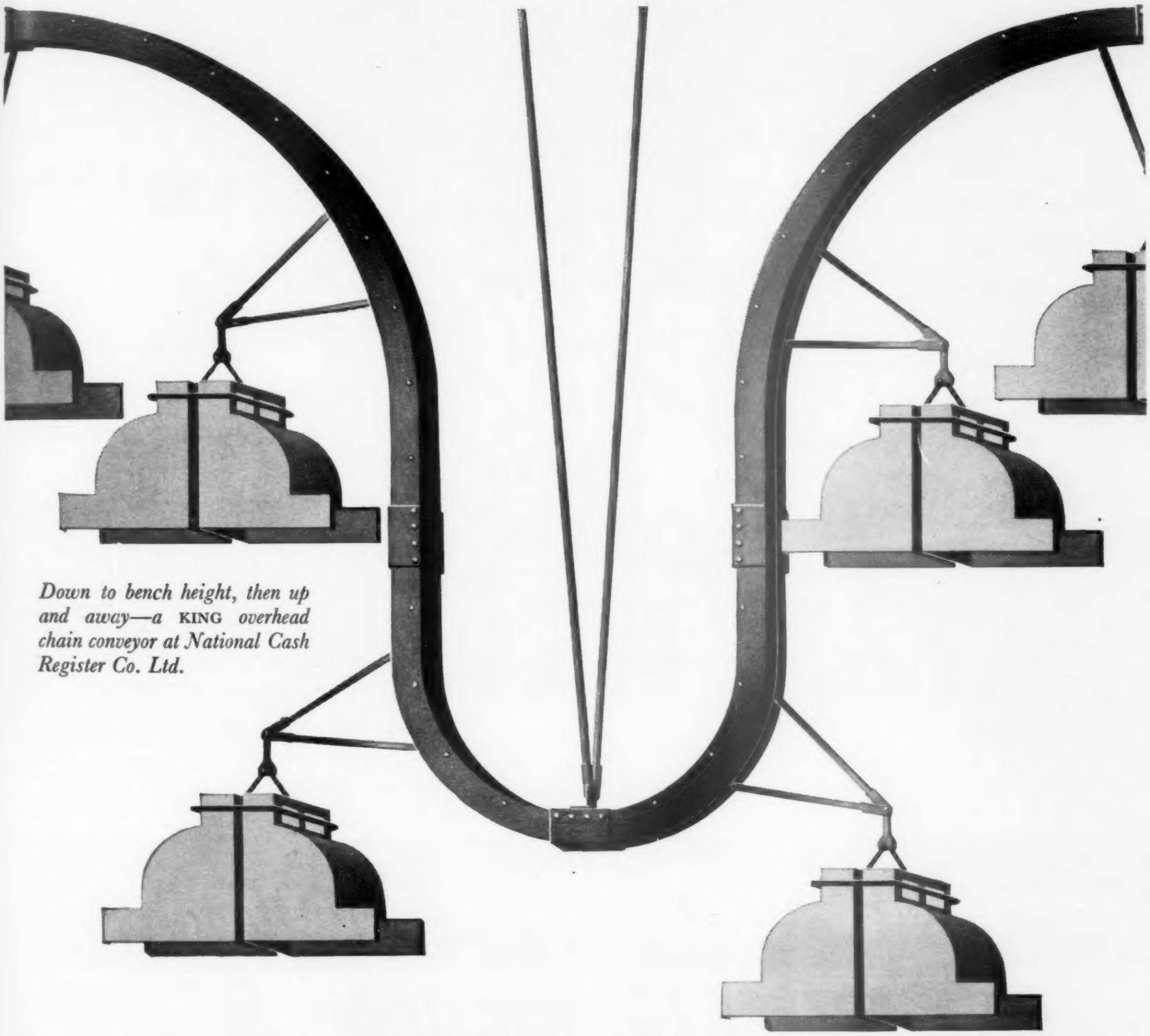

Down to bench height, then up and away—a KING *overhead chain conveyor at National Cash Register Co. Ltd.*

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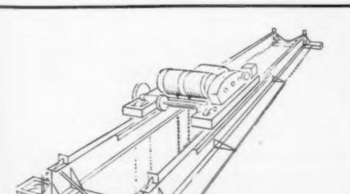
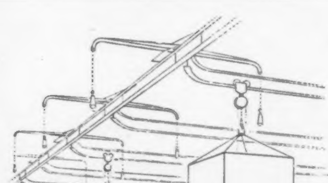


A KING OVERHEAD CRANE



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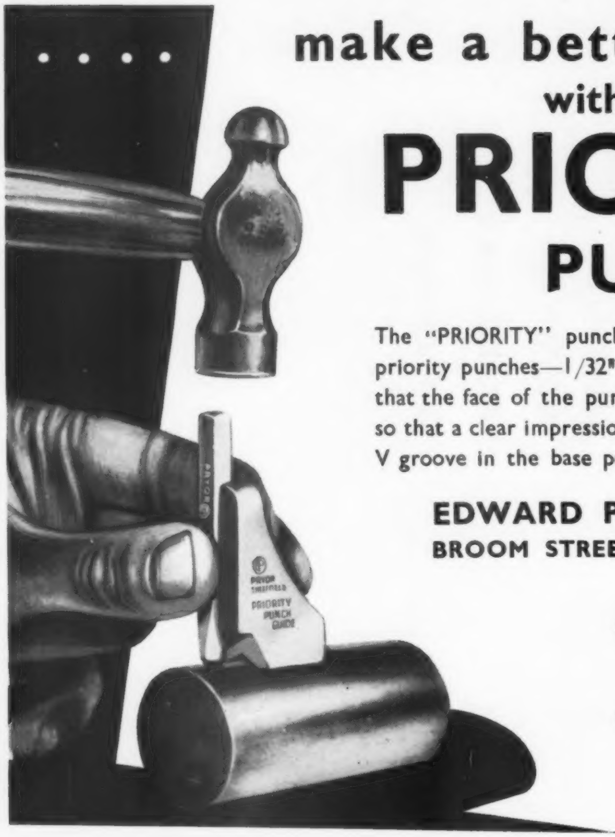

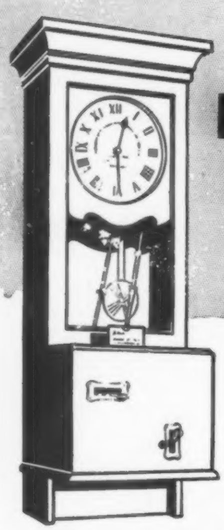

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If so come to a Firm who specialises in such work.

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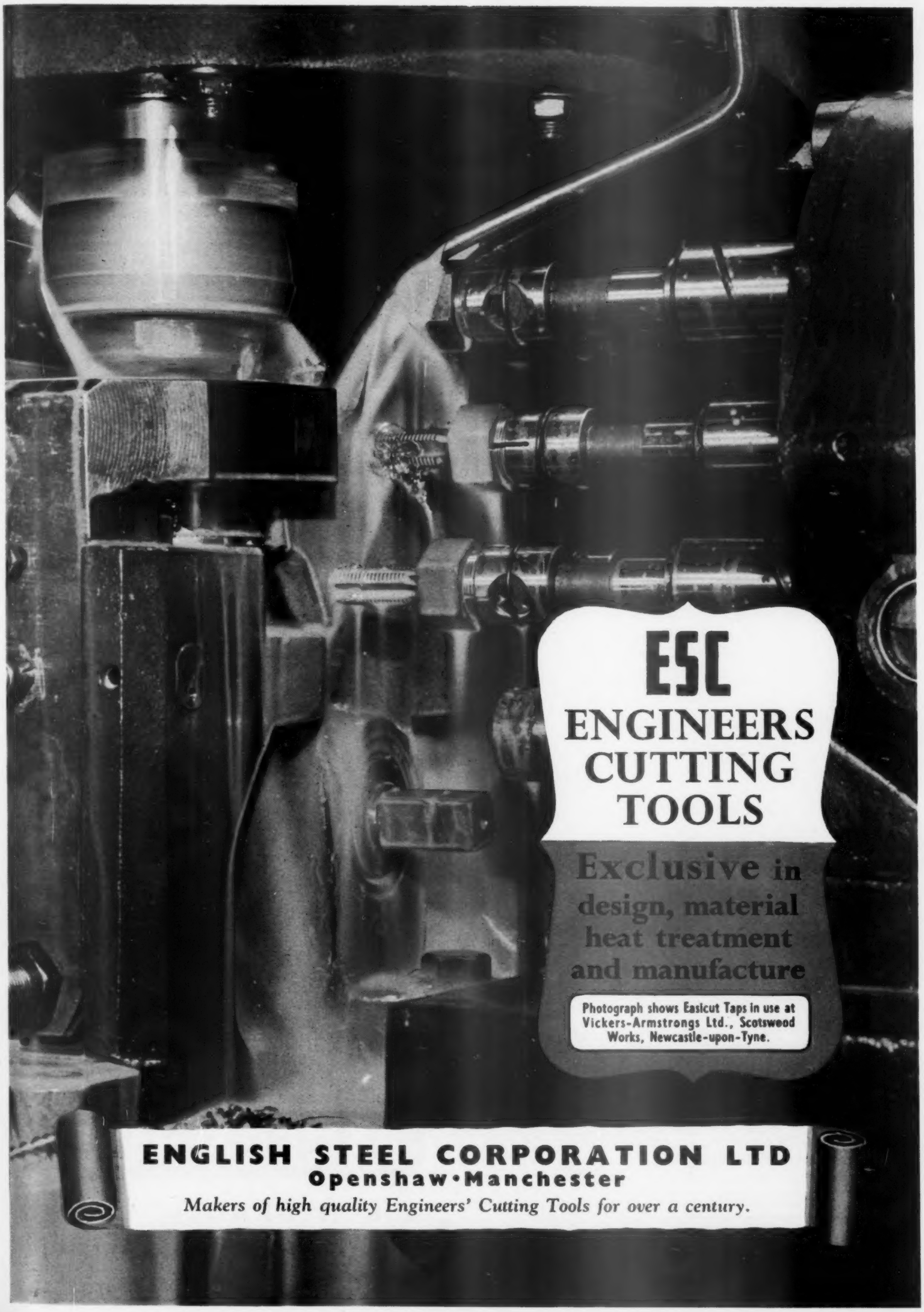
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Only so long as it is efficient. A lamp that lasts a long time, but gives only a poor light, is not worth anyone's money. Metrovick lamps are designed to give the most economic balance of life and light output. Whatever the type, no lamps have a more lasting efficiency than Metrovick.

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S/A:03

Rover Car Factory, Solihull. High intensity lighting in a body spray tunnel by fluorescent lamps in a glazed enclosure.

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The lighting of many processes is vital to the smooth and rapid flow of work and to the quality of the finished product. For example, poor lighting could make a spray tunnel into a bottle-neck — each job taking a little too long, a little portion missed, a return to the spray line — and so the whole production line marks time. Whatever form it takes, good lighting not only helps to provide a satisfactory working environment but is an active production tool.

Fluorescent lighting is as good as daylight — only more consistent. It is efficient; it is economical; and it is *flexible*. You can ' tailor ' it, easily and exactly, to the special requirements of production at all stages.

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Electricity for PRODUCTIVITY

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